

From Department of Women's and Children's Health  
Karolinska Institutet, Stockholm, Sweden

## Mind the gap!

Guideline implementation for peripheral venous catheters  
in paediatric care: documentation, complications, adherence  
and context

Ulrika Förberg



**Karolinska  
Institutet**

Stockholm 2015

All previously published papers were reproduced with permission from the publisher.

Book cover: Hillevi Gebring

Published by Karolinska Institutet

© Ulrika Förberg, 2015

ISBN 978-91-7549-937-6

Printed by E-Print AB 2015

# Mind the gap!

Guideline implementation for peripheral venous catheters  
in paediatric care: documentation, complications, adherence  
and context

## THESIS FOR DOCTORAL DEGREE (Ph.D.)

By

**Ulrika Förberg**

*Principal Supervisor:*

Professor Anna Ehrenberg  
Dalarna University  
School of Education,  
Health and Social studies

*Co-supervisors:*

Professor Lars Wallin  
Dalarna University  
School of Education,  
Health and Social studies

PhD Maria Unbeck  
Karolinska Institutet  
Department of Clinical Sciences,  
Danderyd Hospital,  
Division of Orthopaedics

PhD Britt-Marie Ygge  
Karolinska Institutet  
Department of Women's  
and Children's Health

*Opponent:*

Professor Anna Forsberg  
Lund University  
Faculty of Medicine,  
Department of Health Sciences

*Examination Board:*

Professor Boel Andersson Gäre  
Jönköping University  
School of Health Sciences  
Quality Improvement within  
Health and Welfare

Ass. Professor Bo Vikström  
Karolinska Institutet  
Department of Oncology-Pathology

Professor Ewa Idvall  
Malmö University  
Faculty of Health and Society



*Questions of science, science and progress  
do not speak as loud as my heart*

The Scientist, Coldplay



# ABSTRACT

**Introduction** There is a knowledge translation gap between evidence, based on research findings and clinical practice. Clinical practice guidelines (CPGs) have been proposed as a strategy to condense and disseminate research findings. However their existence alone does not minimise the gap, they have to be implemented in everyday practice. Registered nurses' (RNs) work context influences their research use, but little is known on what contextual factors that influence RNs' adherence to CPGs. Computer reminders have shown potential to minimise the knowledge translation gap, but insights into their effect on patients' outcomes, RNs' adherence and in what context they are most effective is still understudied.

**Aim** to evaluate the effects of implementing recommendations from a CPG for peripheral venous catheters (PVCs) as reminders in electronic patient records (EPR) and to describe factors of importance for the implementation process and outcomes.

**Methods** the setting for all four papers was a large paediatric university hospital in Sweden. Data for paper I was collected from 14 inpatient units through observations of patients and PVCs, and audit of EPRs. This was carried out at baseline and then two times after implementing a documentation template for PVCs. Data on PVCs and patients for paper II were retrieved from the EPR at 12 inpatient units, divided into neonatal and paediatric units. Paper III was a cross-sectional survey, including 23 in- and outpatient units. Data was collected through a questionnaire concerning RNs' adherence to CPG recommendations and their work context, measured by the Alberta Context Tool (ACT). Paper IV was a cluster randomised study, at 12 inpatient units, with computer reminders based on the CPG. A stratified randomisation of units, based on occurrence of PVCs, was performed. The primary outcome was documented signs and symptoms of PVC-related complications at removal and secondary outcome was RNs' adherence to the CPG, and their work context measured by the ACT.

**Results** A statistical, not clinical, significant increase of PVCs with complete documentation was the result of the PVC template. One of the 22 complications observed at baseline was documented and none of the complications ( $n=17$  and  $n=9$ ) post-intervention (paper I). Just over one-third (35.4%) of the patients were affected by a PVC-related complication, with infiltration and occlusion occurring most frequently. Complications were more common in younger age patients (paper II). Work context, in the form of structural and electronic resources, information sharing activities, and evaluation, was in different ways associated with RNs' adherence to the CPG recommendations (paper III). Ninety-one percent of the RNs adhered to the CPG recommendation of disinfection of hands, 64% to usage of disposable gloves and 54% to daily inspection PVC insertion site (paper III). There was no significant effect of the computer reminders, neither on PVC-related complications nor on RNs' adherence to the guideline recommendations (paper IV). RNs score of their context in both groups (intervention and control) varied from moderately low to moderately high.

**Conclusion** The EPR did not provide accurate data on PVCs either before or after the implementation of a PVC template. PVC-related complications, specifically infiltration and occlusion, were common, particularly among younger aged patients. RNs adhered to the recommendation on disinfection of hands, while the use of disposable gloves and daily inspection of PVC insertion site showed greater improvement potential. Diverse contextual factors were in different ways associated with RNs' adherence to the CPG recommendations. The computer reminders did not have any significant effect on PVC-related complications, or on RNs adherence to the CPG recommendations.

## LIST OF SCIENTIFIC PAPERS

This doctoral thesis is based on the following original papers, which will be referred to in the text by their Roman numerals (I-IV):

- I. **Förberg U.**, Johansson E., Ygge B-M., Wallin L. & Ehrenberg A.  
Accuracy in documentation of peripheral venous catheters in paediatric care: An intervention study in electronic patient records.  
*Journal of Clinical Nursing*, 2012 May; 21(9-10): 1339-44.
- II. Unbeck M., **Förberg U.**, Ygge B-M., Ehrenberg A., Petzold M. & Johansson E.  
Peripheral venous catheter related complications are common among paediatric and neonatal patients.  
*Acta Paediatrica*, 2015 Feb 5. doi: 10.1111/apa.12963. [Epub ahead of print].
- III. **Förberg U.**, Wallin L., Johansson E., Ygge B-M., Backheden M. & Ehrenberg A.  
Relationship between work context and adherence to a clinical practice guideline for peripheral venous catheters among registered nurses in paediatric care.  
*Worldviews on Evidence-Based Nursing*, 2014 August; 11(4): 227-39.
- IV. **Förberg U.**, Unbeck M., Wallin L., Johansson E., Petzold M., Ygge B-M. & Ehrenberg A.  
Effects of computer reminders on complications of peripheral venous catheters and nurses' adherence to a guideline in paediatric care - a cluster randomised study.  
*Submitted*.



# TABLE OF CONTENTS

<b>Preface</b>	<b>1</b>
<b>1 Introduction</b>	<b>2</b>
1.1 Evidence-based practice	2
1.1.1 Knowledge translation gap	3
1.2 Clinical practice guidelines	4
1.3 Knowledge translation theories	4
1.3.1 PARIHS framework	5
1.4 RNs' work context	6
1.5 Intervention strategies for implementation	7
1.5.1 Computer reminders	8
1.5.2 Evaluating interventions	9
1.5.3 Patient records	10
1.6 CPG for peripheral venous catheters in paediatric care	11
<b>2 Rationale</b>	<b>13</b>
<b>3 Aims</b>	<b>14</b>
3.1 Specific aims	14
3.2 Outcome measures	14
<b>4 Method</b>	<b>15</b>
4.1 Study settings	15
4.2 Interventions	16
4.2.1 The PVC template	16
4.2.2 The computer reminders	17
4.3 Study participants	19
4.3.1 Paper I	19
4.3.2 Paper II	19
4.3.3 Paper III	21
4.3.4 Paper IV	21
4.3.4.1 Sample size calculation and randomisation	21
4.4 Data collection and analysis	22
4.4.1 Paper I	23
4.4.1.1 Data collection	23
4.4.1.2 Data analysis	23
4.4.2 Paper II	23
4.4.2.1 Data collection	24
4.4.2.2 Data Analysis	24
4.4.3 Paper III	25
4.4.3.1 Data collection	25
4.4.3.2 Data analysis	26

4.4.4	Paper IV	27
4.4.4.1	Data collection	28
4.4.4.2	Data analysis	28
<b>5</b>	<b>Ethical considerations</b>	<b>30</b>
<b>6</b>	<b>Findings</b>	<b>31</b>
6.1	Accuracy and completeness in PVC documentation	31
6.2	PVCs, dwell time, reasons for removal and factors associated with PVC-related complications	31
6.2.1	Characteristics of PVCs	31
6.2.2	Dwell time	32
6.2.3	Reasons for removal	33
6.2.4	Factors associated with PVC-related complications	33
6.2.4.1	Infiltration	33
6.2.4.2	Occlusion	34
6.3	RNs' adherence and work context	35
6.3.1	Adherence	35
6.3.2	Context	35
6.3.3	Relationship between adherence and context	36
6.4	Effects of the computer reminders	37
6.4.1	PVC-related complications	37
6.4.2	RNs' adherence	38
6.4.3	Context	39
<b>7</b>	<b>Discussion</b>	<b>40</b>
7.1	Accuracy and completeness of PVC documentation	40
7.2	PVC-related complications	41
7.3	The influence of context	42
7.3.1	Evidence for the CPG	42
7.3.2	Context	43
7.3.3	Context and RNs characteristics in relation to CPG adherence	45
7.3.4	Staff turnover	45
7.4	The computer reminders	46
7.5	Methodological considerations	48
<b>8</b>	<b>Conclusions</b>	<b>50</b>
<b>9</b>	<b>Implications for clinical practice</b>	<b>51</b>
<b>10</b>	<b>Future research</b>	<b>52</b>
<b>11</b>	<b>Acknowledgements</b>	<b>53</b>
<b>12</b>	<b>References</b>	<b>55</b>

## **LIST OF ABBREVIATIONS**

ACT	Alberta Context Tool
CDSS	Clinical Decision Support System
CPG	Clinical Practice Guideline
EBP	Evidence-Based Practice
EPR	Electronic Patient Record
OR	Odds Ratio
PARIHS	Promoting Action on Research Implementation in Health Services
PVC	Peripheral venous catheter
RN	Registered Nurse



## PREFACE

My journey for this thesis started in 2005 when I was working as a registered nurse (RN) at Sydney Children's Hospital. The hospital had clinical practice guidelines (CPGs) for almost every nursing procedure and I had to read and prove that I understood a guideline before getting signed off and thus permitted to perform that special nursing procedure. My experience of Swedish healthcare was that there were very few CPGs for nursing procedures and that in such cases where guidelines did exist there was no routine to check that RNs had studied and understood the guidelines.

After I returned to Sweden I studied health promotion and wrote my thesis on sources of knowledge among RNs in paediatric care. I wanted to study where RNs gained knowledge when there were no national or hospital wide guidelines for paediatric care. My thesis resulted in a position as a project manager to develop the first hospital wide guidelines for central venous catheters in paediatric care. It was during this process that I came into contact with my supervisors and this led to the PhD project. The project focused on investigating the effects of implementing recommendations from one guideline as computer reminders in electronic patient record (EPR).

This PhD project went under the title RISCC - Reminder Implementation for Safety in Child Care. Written information, presentations and data collections included a bright pink colour and the logo of a child's hand with a peripheral venous catheter (PVC). Most RNs at the paediatric hospital where these studies took place refer to the project as the "the pink questionnaire" or "the pink mouse pads".



# 1 INTRODUCTION

The four papers included in this thesis deal with different aspects of implementing a guideline for PVC in paediatric care as reminders in the EPR. In order to measure the effect of the intervention, PVC-related complications were chosen as a primary outcome. The first paper investigated how accurately the EPR reflected the occurrence of PVCs and complications in paediatric care, while the second paper focused on PVC characteristics and reasons for PVC removal based on EPR data. The third paper examined RNs' adherence to recommendations from the CPG for PVC as well as their perceptions of their work context. The last paper investigated the effect of introducing recommendations from the CPG for PVCs as computer reminders integrated in EPRs.

## 1.1 EVIDENCE-BASED PRACTICE

All healthcare professionals in Sweden are, according to the Patient Safety Act [1], obliged to practice in accordance with scientific and proven experience. Healthcare professionals work must be based on scientific knowledge and proven experience and they are personally responsible for their own actions [1]. It is more than 20 years since the evidence-based medicine, also referred to as the evidence-based practice (EBP) group announced a 'new paradigm' for teaching and practising clinical medicine. Clinical practice was no longer to be based on traditions, anecdotes, and theoretical reasoning from basic sciences. It was to be based on evidence from high quality randomised controlled trials and observational studies, in combination with clinical experience and the needs and wishes of patients [2]. A frequently cited definition of EBP is that of Sackett et al. [3, p.71]:

*'The practice of evidence based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research. By individual clinical expertise we mean the proficiency and judgment that individual clinicians acquire through clinical experience and clinical practice'.*

The authors argue that EBP integrates the best external evidence with individual clinical expertise and patients' choice. But one of the most consistent findings from healthcare research today is the failure to translate research findings into clinical practice [4]. Different terms have been used in order to describe the efforts of reducing this gap, for example quality improvement, knowledge utilisation, research utilisation, implementation of research and knowledge translation, which has gained recognition globally over the last decades [4]. Sung et al. [5] divides translation research into T1, which refers to the translation of basic biomedical research into clinical science and knowledge and T2, which refers to the translation of new clinical science and knowledge into improved health. In this thesis knowledge translation research referred to as T2 will be used.

### 1.1.1 Knowledge translation gap

A result of the knowledge translation gap is that patients fail to benefit optimally from advances in healthcare. Studies have suggested that approximately 30–40% of patients do not receive care according to scientific evidence [6, 7]. Close to one out of ten patients admitted to Swedish hospitals during 2013 suffered from an adverse event during their stay and over half of these events were considered avoidable [8]. Adverse events are defined as an unintended injury or complication, which results in disability, death or prolonged hospital stay and is caused by healthcare management rather than patient's disease [9]. The total cost for longer admissions due to adverse events in 2013 was 11.5 billion Swedish crowns. This means that patients whose hospital stay was prolonged due to an adverse event occupied 13.1% of all hospital beds [8]. There is also evidence that around 20-25% of patients may get unnecessary or potential harmful healthcare [6, 7].

According to the Swedish National Board of Health and Welfare (Socialstyrelsen) there were more than 180000 RNs in 2013, which makes nursing the dominant healthcare profession in Sweden [10]. These numbers ensure that what RNs do and do not do will most likely have an impact on patient care and outcomes. A systematic review concerning RNs use of research in clinical practice has summarise that the use have been relatively consistent as moderate-high over the last decades [11]. The authors are however very cautious as they state that the results are overly optimistic, due to methodological problems in the majority of the included studies. The authors emphasis that there is a need for standardised measurements of research use and well-designed studies that examines RNs' use of research and its impact on patients' outcomes. The authors conclude that the relatively unchanged self-reported research use is troubling given the fact that major efforts have been made the past 15 years on EBP.

Nursing education in many European countries, including Sweden are Bachelor degree programs, including courses in research methodology, a thesis resulting in a Bachelor's degree, and a move toward more self-directed and life-long learning. Studies from a Swedish national cohort of RNs during their first two years post graduation in Sweden showed that the extent of self-reported research utilisation was strikingly low [12]. Another study by the same research group studied RNs during their first five years of professional practice and these results showed a clear trend towards increased research use after more than two years. The authors conclude that this supports previous research that newly graduated RNs go through a 'transition shock,' which reduces their ability to use research findings in clinical work [13]. Rudman et al. [14] investigated RNs extent of EBP during their first five years and discovered that it remained unchanged on a relatively low level. The exception was that among these RNs, 80% stated that they used other sources of information regularly every month, which was assumed to be explained by 'asking colleagues', was exemplified as one of these sources. Studies have consistently shown that RNs rely on sources of knowledge that are embedded in the organisation, such as in-service education, procedure manuals, CPGs and discussions with fellow RNs [15-17]. The fact that colleagues are a common source of

knowledge is a concern, as colleagues do not necessarily provide information based on research [18].

There are several barriers for RNs use of research in healthcare and the most frequently reported barriers are; insufficient time to implement new ideas and/or to read research, lack of authority to change nursing procedures, that statistical analyses are not understandable, and that the relevant literature is not compiled in one place [19].

## **1.2 CLINICAL PRACTICE GUIDELINES**

CPGs have consistently been described as useful tools for bridging the knowledge translation gap within healthcare settings [20, 21]. CPGs are defined by the Institute of Medicine [22, p.38] as:

*‘systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances’*

The idea with CPG is to improve the effectiveness and efficiency of healthcare practice while reducing inappropriate variations [23]. CPGs appear to be one of the most promising and effective tools for improving the quality of healthcare as they have the potential to improve healthcare delivery and outcomes [7]. In Sweden there are national and regional CPGs to support healthcare, but these guidelines focus mainly on specific medical conditions and recommended treatments directed to physicians. The handbook for healthcare (Vårdhandboken) contains web based CPGs designed to help meet national goals for health and medical care in Sweden. The target group for this handbook is healthcare professionals that have a basic level of education and its contents is primarily directed to adult patient care [24]. Currently there are only a few national and regional CPGs directed to paediatric nursing procedures.

As CPGs existence alone is not a guarantee to ensure use, they have to be implemented in the daily practice of healthcare professionals. Some estimates indicate that two-thirds of organisations' efforts to implement change fail [25] and that chosen strategies for implementation are based on beliefs rather than on evidence about the effectiveness of different approaches [26].

## **1.3 KNOWLEDGE TRANSLATION THEORIES**

According to Graham and Logan [27], the literature covers two broad categories of knowledge translation theories and models: classical and planned. The classical theories or models of change are passive as they explain or describe the naturalistic process of change. One of the most well known classical theories is Rogers's diffusion of innovations model [28]. Diffusion is the process by which an innovation is communicated through certain



channels over time and people pass through five stages when deciding whether to adopt an innovation. According to Rogers an innovation is more quickly adopted if it is compatible with current practices, seen as more advantageous than the current practice, easy to use, observed by others to be in use and if it can be easily tested before being formally adopted [28].

Planned theories or models provide a set of logically interrelated concepts that systematically explain the means by which planned change occurs [27]. These theories acknowledge that the organisational environment of practice is of importance when implementing a change.

Examples of planned change theories or models are: Green's Precede-Proceed model [29, 30], Logan and Graham's Ottawa Model of Research Use [31] and the Promoting Action on Research Implementation in Health Services (PARIHS) framework, originally developed and described by Kitson et al. [32] and Rycroft-Malone et al. [33].

### **1.3.1 PARIHS FRAMEWORK**

The PARIHS framework attempts to make sense of the factors involved in implementing EBP and proposes that successful implementation is dependent upon the nature of the evidence being used, the quality of context and the type of facilitation required to enable a successful change process [34]. The PARIHS framework can be explained as a function of the relationship between Evidence, Context, and Facilitation [34], where the first two elements are on a continuum of low to high and Facilitation from task-oriented to holistic. The framework suggests that successful implementation is more likely to occur when evidence and context are considered high. The rationale for choosing the PARIHS framework was that the model is developed for implementing EBP in healthcare, more specifically in nursing care. Also the notion that context influences successful implementation of research based knowledge and that the two first elements of the framework played a central part in the included studies of this thesis.

PARIHS describes *Evidence* as research as well as clinical and patient experiences. High evidence is when research is well conceived and conducted and when there is a consensus about it. Clinical experience should be made explicit and verified through critical reflection, critique and debate. Patient experience is when patient preferences are used as part of the decision-making process and when patient narratives and experiences are seen as a valid source of evidence. *Context*, is the environment or setting in which people receive healthcare services or in the environment or setting in which the proposed change is to be implemented. Context comprises three main dimensions: leadership, culture and evaluation [35]. The assumption is that the more favourable the context, the better the conditions for successful implementation. Where there is clarity of roles, decentralised decision making, valuing of staff, transformational leaders and a reliance on multiple sources of information the chances of a successful implementation are more likely. How a problem is caused and sustained and whether that problem is susceptible to an intervention, basically if any intervention could

work may all depend on the context [36]. *Facilitation* refers to the process of enabling the implementation of evidence into practice and facilitators play a key role in the implementation process. Facilitation consists of three main dimensions: purpose, role as well as skills and attributes [37].

## **1.4 RNS' WORK CONTEXT**

RNs are key players in the effective functioning of complex hospital organisations, and their ability to provide good patient care is influenced by the context in which they practice. RNs' work context in hospitals has been widely discussed internationally as an important factor for their use of research [38-40] their job satisfaction [41], as well as patient satisfaction with care [42, 43], and patient outcomes [44-46]. Aiken et al. [47] found that the likelihood of patients dying within 30 days of admission was 14% lower in hospitals where RNs had rated their work context higher than in hospitals with lower scores. A recent published study on healthcare associated infections in critical care, showed that they were less likely to occur in work context that were more favourable for RNs [48]. The authors argue that these findings demonstrate that efforts to increase the quality of work context are a way to minimise the frequency of healthcare associated infections. Improvement of RNs' work context is suggested to be a relatively low cost strategy to improve safety and quality in hospital care and to increase patient satisfaction [49]. PARIHS has been used as a theoretical framework for several instruments in order to measure context within healthcare settings. The Context Assessment Index (CAI) was developed to evaluate the context and to assess healthcare organisations' readiness for use of evidence [50]. CAI measures context through five main scales; collaborative practice, evidence-informed practice, respect for the person, practice boundaries and evaluation. The Organizational Readiness to Change Assessment (ORCA) instrument is developed in order to measure readiness for implementation of evidence-based healthcare interventions, through the main scales evidence, context and facilitation [51, 52]. The Alberta Context Tool (ACT) assess context within complex healthcare settings, with the assumption that context is a central influence on healthcare professionals use of knowledge [53]. The ACT adds five additional dimensions to the PARIHS elements of context (leadership, culture, and evaluation) namely, information sharing interactions, information sharing activities, information sharing processes, structural and electronic resources and organisational slack, defined as staff, space and time. The paediatric ACT is designed for acute care settings and has previously been used to investigate the influence of organisational context on RNs use of research in Canadian paediatric hospitals [40, 54-56]. The paediatric ACT has been used in this thesis in order to measure RNs' work context.

Context is not only an important factor when it comes to patient safety, it is also crucial to understand the work context when designing interventions and when assessing whether an intervention strategy that was effective in one setting might work in others.

## 1.5 INTERVENTION STRATEGIES FOR IMPLEMENTATION

A systematic review has identified a range of intervention strategies to support the dissemination and implementation of CPGs [57], but there is still limited understanding regarding what approaches that are most effective in what context [20, 58-60].

The Cochrane Effective Practice and Organization of Care group (EPOC) aims to prepare and maintain systematic reviews of interventions designed to improve professional practice and the delivery of effective healthcare service. The EPOC group has developed a taxonomy and a checklist for interventions that are thought to facilitate the use of known knowledge and help to overcome barriers to its adoption in clinical settings [61]. They have grouped the intervention strategies into five main categories, namely:

**Financial interventions** are divided into two subgroups, provider and patient interventions, and include changes in how professionals are reimbursed, incentives and penalties.

**Organisational interventions** involve a change in the structure or delivery of healthcare, a change in who delivers healthcare, how care is organised or where care is delivered. These interventions are divided into two subgroups; provider oriented interventions and patient oriented interventions.

**Professional interventions** target healthcare professionals through example distribution of educational materials, for more examples see Table 1.

**Regulatory interventions** include changes in medical liability, management of patient complaints, peer review and licensure.

**Structural interventions** include changes to the setting or site of healthcare service delivery

A review on the effectiveness and efficiency of guideline dissemination and implementation strategies for physicians published in 2004 showed that a majority of the strategies resulted in modest to moderate improvements in patient care [57]. The most promising intervention strategy to support guideline implementation was in the form of reminders provided verbally, on paper or on a computer screen.

**Table 1.** Classification of professional intervention strategies for implementation\*

Strategy	Explanation
Distribution of educational materials	Distribution of published or printed recommendations for clinical care, including CPGs, audio-visual materials and electronic publications.
Educational meetings	Participation in conferences, lectures, workshops or traineeships.
Local consensus processes	Participating in discussion to ensure agreement of chosen clinical problem and the approach to manage that problem.
Local opinion leaders	Nomination of colleagues as ‘educationally influential’. The investigators must explicitly state that the colleagues have identified the opinion leaders.
Patient mediated interventions	New clinical information (not previously available) collected directly from patients and given to healthcare professionals e.g. scores from an instrument.
Audit and feedback	Any summary of clinical performance of healthcare over a specified period of time. The information may be obtained from patient records, computerised databases, or observations from patients.
Reminders	Patient or encounter specific information, provided verbally, on paper or on a computer screen.
Tailored	Use of personal interviewing, group discussion, or a survey of the targeted group in order to identify barriers to change and subsequently design an intervention that addresses the identified barriers.
Mass media	Varied use of communication to reach great numbers of people including television, radio, newspapers, posters, leaflets, and booklets, alone or in conjunction with other interventions; targeted at the population level.

\* Classification of professional interventions from EPOC taxonomy [61]

### 1.5.1 Computer reminders

In 2009 a Cochrane review was released that investigated the effects of on-screen point of care computer reminders on processes and outcomes of care [62]. Gordon et al. [63, p.4] define computer reminders as:

*‘Patient or encounter specific information, provided via a computer console either visually or audibly, which is designed or intended to prompt a healthcare professional to recall information usually encountered through their general medical education, in the medical records or through interaction with peers, and so remind them to perform or avoid some action to aid individual patient care’.*

The authors’ definition of ‘point of care reminders’ was that they are delivered at the time the clinicians are engaged in the specific target activity, such as documentation in EPR. These reminders prompt healthcare professionals to recall information that they may already know but that could easily be forgotten, or in the case of decision support, provide information or

guidance in an accessible format at a particularly relevant time [62]. The review, which mainly included studies on physicians, concluded that a minority of the interventions showed larger effects of point of care computer reminders and that the majority achieved small to modest improvements in changing healthcare professionals' behaviour. The authors argue that research must identify design features for computer reminders and contextual factors associated with larger improvements in changing professional behaviour. The authors also state that given the difficulties and resources needed in order to change healthcare professionals' behaviour, reminders are a promising strategy, especially given their low cost [62].

Focus in recent years has been on developing and testing computer reminders in the form of Clinical Decision Support Systems (CDSS). CDSS are electronic systems designed to aid practitioners directly in clinical decision making by using patient specific characteristics to generate recommendations [64]. CDSS refers to any electronic system designed to aid directly in clinical decision making by generating patient specific recommendations that are presented to clinicians for consideration.

There are no systematic reviews on the effect of computer reminders on nursing performance or patient outcomes. There are however systematic reviews on CDSS [65, 66], which have shown that CDSS effectiveness in nursing practice is still inconsistent and that further studies are needed in order to identify in which contexts they are most effective. Studies in recent years of CDSS have shown improvement in nursing documentation [67] and patient outcomes [68] and studies of computer reminders have shown effect on RNs' adherence to CPGs [69] and decreased omissions in nursing care [70].

### **1.5.2 Evaluating interventions**

According to Campbell et al. [36] many healthcare activities should be considered as complex interventions and evaluation is therefore very challenging and requires substantial time investment. Different methods can be used in order to identify and measure quality, risks and incidents in healthcare systems and data collection is usually the first step for an organisational learning process [71]. Data collection is necessary in order to provide a basis for prioritising resources, implementing changes and monitoring progress in patient safety outcomes [71]. Two commonly used data collection methods in patient safety and quality work are incidence reporting systems and structured record reviews [72]. Incidence reporting systems refer to the processes and technology involved in the standardisation, formatting, communication, feedback, analysis, learning, response and dissemination of lessons learned from reported risks and incidents within healthcare [73]. Incidence reporting systems in Sweden can provide data on a national, regional and local level, but the scope may differ greatly as national and regional systems mainly focus on identifying rare or severe events, while local systems often can collect more detailed data for a certain healthcare setting. According to the Swedish Patient Safety Act [1] all healthcare professionals are required to

report risk for preventable adverse events, as well as events that have led to or might lead to a preventable adverse event. Healthcare organisations are also required to investigate and report adverse events and risk for adverse events to a higher level. But the underreporting to the incidence reporting systems is a concern, which questions their reliability when measuring patient safety, or evaluating patient safety initiatives or patient outcomes. Structured record reviews are therefore often conducted in order to collect specific data for a certain patient safety issue. Retrospective record reviews can play a vital role in order to identify, categorise and analyse quality and patient safety problems and can provide the basis for healthcare interventions [72]. But retrospective record review of patient records has its strengths and limitations as displayed in Table 2. Record review is a valid data collection method compared to most other methods and give access to detailed information that can be used in order to estimate prevalence and incidence. Record review of patient data collect secondary data, as the primary focus for documentation is not to record outcomes for an intervention. It can be very time consuming if not standardised and/or structured documentation is used, and concerns with reliability will always arise, that is how accurately does the documentation reflecting the clinical practice and/or outcomes for patients [72].

**Table 2.** Strengths and limitations to record review\*

Strengths of record review	Limitations of record review
Use already available data	Rely on documentation quality
Valid compared to most other methods	Hindsight bias
Can yield detailed information	Reliability concerns
Can detect active failures if adequate documentation	Resource extensive for continuously use or on large scale
Can estimate prevalence and incidence	
Can be used to assess the efficacy of interventions	

\*Reference, Unbeck [72]

### 1.5.3 Patient records

Healthcare is an information intensive organisation where large amounts of data are in circulation between and within the professions that are involved in the individual patient care. To ensure that patients receive good and safe care, it is a statutory obligation in Sweden for all healthcare professionals, including RNs, to keep patient records of assessment, decision, intervention and evaluation regarding patient care and treatments. Patient records include all the documents containing information about the patient's health status, other personal circumstances, diagnoses, planned and executed interventions and evaluation of outcomes. The patient record is a tool that should be available to all who are responsible for the different aspects of care and the information should therefore be reliable and easy to understand [74].

A recent study by Sharp et al. [75] with the objective to evaluate the documentation in the EPR for physicians, RNs and nursing assistants. The study was conducted at a Swedish

oncology clinic for adult patients and showed several shortcomings. Findings indicated for example that there was a habit of copying text from others and sometimes with new information inserted and that there was an unsystematic use of templates and terms, where the same type of information could be found in different documentation templates. The authors concluded that the documentation found in the EPR provided an obvious risks for patient safety and that clarity, purpose and a general redesign is needed in order to support communication and improve patient safety.

RNs have for long been recognised as key collectors, generators and users of patient information and the quality and continuity of care is dependent upon the information available. The role of the RN as a provider and coordinator of the care given twenty-four hour a day means that the exchange and transfer of information is a significant nursing activity [76]. Accurate nursing documentation addresses assessments, nursing diagnoses, goals or expected outcomes as well as planning of interventions and evaluation of outcomes, but studies that have evaluated nursing documentation show that EPRs do not serve as a valid source of information concerning patient care and/or outcomes [77-81]. According to Saranto et al. [82], the use of structured nursing terminology can promote standardisation of nursing documentation, as it has proven to support daily workflow, delivery of nursing care and data reuse. A standardised nursing terminology can also facilitate data exchanges in and between clinical settings, which contributes to the continuity of care and patient safety [83]. A result of the findings in the study by Sharp et al. [75] activity plans were introduced into the EPR. Activity plans are designed so that RNs and nursing assistants can easily document planned care and assessments in a structured and standardised way, by creating for example lists, which can easily be signed off when completed and evaluated. One of the biggest benefits with activity plans is that there is no longer a need to document information in free text, and the authors concluded that the introduction of the activity plans contributed to greater clarity and less amount of text in the EPR [75]. Another study has shown similar findings concerning the introduction of computerised nursing care plans, which increased RNs documentation completeness, by more variety of nursing diagnoses, increased documentation of signs and symptoms, related factors and nursing interventions [81].

## **1.6 CPG FOR PERIPHERAL VENOUS CATHETERS IN PAEDIATRIC CARE**

As earlier mentioned, there are few national CPG that give guidance for nursing procedures in paediatric care. A large paediatric university hospital in Sweden developed a CPG for insertion and management of PVCs in 2010. The guideline was the first hospital wide CPG directed to RNs and the objectives were to standardise practice and minimise complications related to PVCs. The CPG was developed by RNs with expert knowledge of PVCs in paediatric care and was based on published research as well as the RNs' professional experiences. The chief executive officer at the university hospital approved the CPG. The CPG contained information concerning PVCs, as well as recommendations on PVC

management, e.g. indication for insertion, sizes and insertion sites as well as instructions for insertion, management and removal and information and recommendations concerning PVC-related complications.

A PVC is a small catheter (flexible tube) placed into a peripheral vein in order to administer medication or fluids. The catheter is introduced into the vein by a needle, which is removed after insertion and the catheter remains in the vein. The PVC is then attached to the patient by taping it to the skin. Most paediatric patients require PVCs for the administration of pharmacological and nutritional support so the insertion, maintenance, removal, replacement and documentation of PVCs are very common procedures that RNs in Sweden perform on a daily basis.

It is essential to maintain optimal function of PVCs in paediatric care as re-insertion is often highly stressful for the patient [84] and that re-insertion of a PVC may lead to considerable procedure-related pain and anxiety, which also is stressful for the staff and the patients' carers [85]. In addition, PVC insertion is a time-consuming procedure [84, 86] and the first-attempt insertion success rate is reported to be only 38.9% in patients up to two-years-of-age [84]. As PVCs in paediatric care should be replaced when clinically indicated [87] it is of high importance that daily inspections of PVCs' insertion sites and function controls are performed regularly. Indwelling PVCs might lead to complications such as infection, infiltration, occlusion or thrombophlebitis that can affect patients' health and wellbeing [88]. The most common individual PVC-related complication among paediatric patients seems to be infiltration, which ranges from 16% to 78% [89-97]. The reported incidence of thrombophlebitis and occlusion varies from 0% to 13% [92, 94, 96-101] and 0.2% to 26% [91, 93, 94, 96, 97, 102] respectively, and infections account for 0% to 8% of PVC-related complications [89, 92, 99, 100, 103, 104].

Although healthcare organisations are obliged to report outcomes and adverse events in medical and nursing treatment, there is currently no register of the occurrence of PVCs and complications at a national or local level. So data from EPRs are needed in order to evaluate the management of PVCs and occurrence of signs and symptoms of PVC-related complications. There are however no studies on the accuracy on PVC documentation in paediatric care, but research among adult patients indicate that patient records are lacking information about insertion and removal in 30–50% of the inserted PVCs [79, 105].



## 2 RATIONALE

EBP should be the basis for Swedish healthcare, but studies from the last decades have shown that there is a knowledge translation gap between evidence, based on research findings, and clinical practice. There are several barriers for RNs knowledge translation and the most prominent ones are lack of time, skills and support to translate research findings into actual practice. CPGs have been proposed as a strategy to condense and disseminate research findings, but their existence alone do not minimise the gap, they have to be adapted and implemented into the everyday practice. It is known that RNs' work context is related their use of research and job satisfaction, but little is known about the relationship between work contextual factors and RNs' adherence to CPGs. Computer reminders might work as a way to support CPG implementation and have shown potential to minimise the knowledge translation gap, but insights into their effect on patients' outcomes, RNs' adherence and in what context they are most effective is still relatively unknown. Therefore, this thesis has the objective to contribute with knowledge concerning what factors in RNs' work context that influence their adherence to a CPG for PVCs. Furthermore, to bring knowledge of the effectiveness of implementing CPG recommendations as computer reminders on patients' outcomes and RNs' adherence in an acute care paediatric context.

### 3 AIMS

The overall aim of this thesis was to evaluate the effects of implementing recommendations from a CPG for PVCs as reminders in EPRs in paediatric care and to describe factors of importance for the implementation process and outcomes.

#### 3.1 SPECIFIC AIMS

The specific aims were to:

- Compare the accuracy and completeness in the recording of PVCs before and after implementing a template for documentation in the EPR (paper I)
- Describe characteristics of PVCs, including dwell time and reasons for removal, and explore factors associated with PVC-related complications (paper II)
- Describe RNs' adherence to a CPG for managing PVCs, the RNs' perceptions of their work context, and the ways that work context and RNs' characteristics related to guideline adherence (paper III)
- Investigate the effects of implementing a CPG for PVCs in the format of reminders integrated in EPRs, on PVC-related complications and RNs' self-reported adherence to the guideline (paper IV)
- Study the relationship between contextual factors and the outcome of the intervention (paper IV)

#### 3.2 OUTCOME MEASURES

<b>Paper I</b>	Documentation of PVCs and related complications
<b>Paper II</b>	Characteristics of patients and documented PVCs, dwell time and PVC-related complications
<b>Paper III</b>	RNs' self-reported adherence to three CPG recommendations for PVCs Context as perceived by RNs
<b>Paper IV</b>	Primary outcome was documented signs and symptoms of PVC-related complications  Secondary outcomes was RNs' self reported adherence to three CPG recommendations for PVCs and their self reported work context

## 4 METHOD

This thesis includes two studies presented in four papers. The first study is presented in paper I and the second study in papers II-IV.

The method section will present the settings, interventions, study participants, data collection and analysis. Table 3 presents an overview of the papers included in this thesis.

**Table 3.** Overview of the papers' design, aim, sample and methods for data collection

Paper	Design	Aim	Sample	Data collection
I	Before and after study	Compare the accuracy and completeness in the recording of PVCs before and after implementing a template for documentation in the EPR	Patients with PVCs	Observations Audit of EPRs
II	Descriptive study	Describe characteristics of PVCs, including dwell time and reasons for removal, and explore factors associated with PVC-related complications	Documented PVCs and patient data	Audit of EPRs
III	Cross-sectional survey	Describe RNs' adherence to a CPG for managing PVCs, the RNs' perceptions of their work context, and the ways that work context and RNs' characteristics related to guideline adherence	RNs	Questionnaire
IV	Cluster randomised study	Investigate the effects of implementing a CPG for PVCs in the format of reminders integrated into the EPR, on PVC-related complications and RNs' self-reported adherence to the guideline. Additional aim was to study the relationship between contextual factors and the outcome of the intervention	Documented PVCs and patient data RNs	Audit of EPRs Questionnaire

### 4.1 STUDY SETTINGS

The Swedish healthcare system is mainly government-funded, though private establishments do exist. Healthcare is organised on three levels: national, regional and local. The national level establishes principles and guidelines for care and sets the political agenda for health and medical care. The Ministry of health along with other government bodies supervises activities at the lower levels, allocating grants and periodically evaluates services to ensure that national goals are met. At the regional level, responsibility for financing and providing healthcare is decentralised to the county councils and regions. A county council/region is a political body whose representatives are elected by the public every four years. The executive board of a county council/region exercises authority over healthcare structure and management, and are responsible for efficient healthcare delivery.

The studies included in this thesis have been conducted at a paediatric division of a large urban university hospital within the Stockholm county council. The paediatric division, also

called hospital, is divided into eight departments with a steering committee that is lead by the Head of the paediatric division/hospital. These eight departments have different specialties such as neonatology, oncology, paediatric surgery, paediatric medicine, orthopaedics, intensive care units, the operating theatre and anaesthetics and paediatric emergency care. The paediatric hospital admits patients from 0 to 18 years of age, with some exceptions for older patients within some diagnostic groups. At the time these studies the hospital had a capacity of approximately 245 beds and consisted of 18-19 inpatients unit, and between 850-940 RNs were employed.

The first transition from paper based patient records to EPR at the hospital took place in 1997 and the current EPR system, TakeCare [106], at the hospital was introduced in 2004.

TakeCare is the most widely used EPR system in Sweden with about 37000 users [106]. The intensive care units at the university hospital used an EPR system called CliniSoft [107] and the paediatric intensive care unit joined that system in 2006 and the neonatal intensive care units in 2011. There were computers with access to the EPR system at every unit, though the number of computers per nursing station varied throughout the hospital.

## **4.2 INTERVENTIONS**

Previous research findings on PVC documentation among adult patients indicated that EPR did not accurately reflect patient care and outcomes and suggestions concerning development and implementation of standardised terms and guidelines were recommended in order to increase the accuracy and completeness of PVC documentation [79].

### **4.2.1 The PVC template**

In order to measure the outcome variable in paper IV, namely PVC-related complications we needed to investigate the accuracy of PVC data from EPRs. A template for documenting PVCs was activated in the EPR system TakeCare in May 2009 as part of paper I (Figure 1). The template was as an alternative way to document PVCs, meaning that PVCs could still be documented in e.g. free text. In order to evaluate the management of PVCs and prevalence of complications, a minimum of information concerning insertion date, side, site and size is needed [105, 108, 109]. This meant that the fields for documenting PVC insertion in the template were made mandatory, meaning that they had to be documented in order to save and close the template (Figure 1). Because of EPR design restrictions, the fields relating to PVC removal could not be made mandatory. Insertion and removal dates needed to be manually entered. The other fields provided multiple drop-down options where one option had to be selected (Table 4). The template could be re-opened at any stage to check previously saved information or to enter information relating to PVC removal.

Nurse Managers were informed about the PVC template at their monthly meetings. RNs with special responsibility for documentation and hygiene were instructed on the template and received instruction leaflets, on how to document in the template, to distribute in their units (paper I).

Term	Field	Comment
Insertion date*	20091105	
Side*	Right	
Size*	24G, yellow	
Site*	Foot	
Removal date	20091108	
Removal cause	Infiltration	

\* Mandatory fields

**Figure 1.** The PVC template in 2009 (paper I)

#### 4.2.2 The computer reminders

The PVC template was further developed in 2011 (paper IV) by adding drop down fields for reason for insertion, insertion attempts and daily inspection day 1-10 (more days could be added) (Figure 2 and Table 4). These alterations were made on request from users as well as further attempts to develop and evolve the structure and standardised documentation of PVCs.

The reminders were integrated in the PVC template at the intervention units as part of a cluster randomised study (paper IV). The reminders were designed as speech bubbles that appeared on the screen for 20 seconds when the cursor was moved over the template (Figure 2). The reminders had a font and a background colour that deviated from the template. They consisted of five recommendations originating from the CPG for PVCs: disinfection of hands, use of disposable gloves, fixation of and choice of PVC size, inspection of insertion site and documentation of removal cause (Table 4). These recommendations were chosen as reminders as the adherence to them was presumed to have the greatest impact on reducing PVC-related complications [87].

Nurse Managers at all included units were informed about the study in general and no specific information was given to the intervention units. Mouse pads containing information on how to document PVCs in the PVC template were distributed to all units (paper IV).

PVC - 19800724-xxxx FÖRBERG, ULRIKA

Sign Sign & create new X

2014-06-21 12:11

Term	Field	Comment
Insertion date*	20140618	
Reason for insertion*	Intravenous therapy	
Insertion attempts*	2 attempts	
Side*	Right	
Size*	24G, yellow	
Site*	Foot	
Removal date	20140621	
Removal cause	Infiltration	
Inspection day 1	No signs/symptoms of complication	
Inspection day 2	No signs/symptoms of complication	
Inspection day 3	Swelling	
Inspection day 4		
Inspection day 5		
Inspection day 6		
Inspection day 7		

**Reminder!** X

Disinfect your hands and forearms, use disposable gloves. Disinfect the insertion area thoroughly. Fixate the PVC well, make sure that the insertion site can be observed

\* Mandatory fields

**Figure 2.** The PVC template and one of the reminders in 2011 (paper IV)

**Table 4.** Fields for documentation in the PVC template and the related reminders

Fields	Text field and drop-down options	Reminders at intervention units
Insertion date	yyyy-mm-dd	<b>Reminder!</b> Disinfect your hands and forearms, use disposable gloves. Disinfect the insertion area thoroughly. Fixate the PVC well, make sure that the insertion site can be observed
Reason for insertion <sup>a</sup>	Intravenous therapy /preparation for surgery or examination /risk that the patient can deteriorate /no obvious reason /other reason (free text)	<b>Reminder!</b> Always use aseptic technique when managing the PVCs and the catheter system
Insertion attempts <sup>a</sup>	1 / 2 / 3 / 4 / 5 / Other number (free text)	
Side	Right/Left	
Size	26G(Purple) /24G(Yellow) /22G(Blue) /20G(Pink) /18G(Green) /17G(White) /16G(Grey)	<b>Reminder!</b> Chose as short and thin PVC as possible
Site	Hand /Wrist /Forearm /Bend of arm /Groin /Foot /Ankle /Scalp /Lower part of the leg /Other site (free text)	
Removal date	yyyy-mm-dd	<b>Reminder!</b> Document the reason for removal
Removal cause	Completed treatment /Occlusion /Pain /Suspicion of infection /Thrombophlebitis /Thrombosis /Infiltration /Other reason for removal (free text)	
Inspection day, 1-10 <sup>a</sup>	No signs or symptoms of complications /Erythema /Swelling /Heat /Pain /Pain at palpation /Pus or liquid /Other sign or symptom (free text)	<b>Reminder!</b> Remove the outer dressing, inspect the insertion site and flush the PVC. Ask the patient for PVC-related pain and pain at palpation. Assess whether the PVC should remain in situ

<sup>a</sup> Introduced at all units in 2011 (paper IV)

### **4.3 STUDY PARTICIPANTS**

This thesis involved patients with PVCs (papers I, II, IV) and RNs (papers III, IV) at a paediatric university hospital. This section will describe the inclusion and exclusion criteria for each paper as well as the study periods, participants and the final samples. Table 5 presents the participants, final sample and the data collection periods for paper I-IV.

#### **4.3.1 Paper I**

This paper involved all 19 inpatient units at the paediatric hospital that used the EPR system, TakeCare to document PVCs, excluding two intensive care units and the operating theatre/anaesthetic unit. The advanced home care and the emergency department were excluded due to logistical problems concerning patient flow and location of patients, which resulted in a final sample of 14 inpatient units.

Inclusion criteria for patients with PVCs were that they were admitted to one of the 14 and were available at the unit at the time for data collection units, One or several PVCs from the same patient could be included. Exclusion criteria were if the patients were not to be disturbed because of their medical conditions or if the patients/carers chose not to participate (Table 5). Final sample of PVCs for the three data collection occasions were 65 PVCs at baseline in 2008, 66 PVCs at post-intervention I in 2009, and 45 PVCs at post-intervention II in 2010.

#### **4.3.2 Paper II**

This study involved all 19 inpatient units at the paediatric hospital that had access to the PVC template in the EPR system TakeCare, excluding four intensive care units, one neonatal unit and the operating theatre/aesthetic unit. The emergency department was also excluded, as the RNs did not care for patients with PVCs for a longer period of time. After exclusion, the final sample resulted in 12 inpatient units, out of which two were neonatal units and one a neonatal intensive care unit. These units admitted premature patients, born between gestational week 23 and 36 plus 6 days, together with newborn infants of <2 weeks old who required highly specialised care.

PVC data were based on the total sample of 5269 PVCs retrieved from the EPR for paper IV (Table 5). Inclusion criteria for paper II was one PVC per patient, so patients who had more than one PVC documented in the template, consecutively or concurrently, the first registered PVC with complete documentation of insertion date, removal date and reason for removal was included. Another exclusion criteria were patients older than 18 years of age. The final sample consisted of 2032 PVCs/patients, whereas 484 patients were admitted at neonatal units and 1548 at paediatric units.

**Table 5.** Study participants, final sample and data collection periods for the two studies presented in four papers

Study I		Study II	
<b>Paper I, PVCs</b> 14 units	<b>Paper II, PVCs/patients</b> 12 units	<b>Paper III, RNs</b> 23 units	<b>Paper IV, PVCs/RNs</b> 12 units
<b>Baseline, 2008</b> No of patients, n=182 Eligible patients, n=54 Observed PVCs, n=65	<b>2009-2010 &amp; 2011-2012</b> Total sample, n=5269 Not eligible PVCs/patients: <1 PVC/patient, n=1543 Incomplete documentation, n=1688 Patients >18 years, n=6	<b>2009-2010</b> Total sample, n=886 Not eligible, n=247 Received the Q, n=639 Non respondents, n=266 Final sample, n=373 (58.4%)	<b>Intervention group</b> 6 units  <b>PVCs baseline, 2010</b> Total sample, n=1213 Incomplete documentation, n=587 Final sample, n=626
<b>Intervention, 2009</b> Template for documenting PVCs activated at all units			<b>Control group</b> 6 units  <b>PVCs baseline, 2010</b> Total sample, n=1213 Incomplete documentation, n=489 Final sample, n=724
<b>Post-intervention I, 2009</b> No of patients, n=154 Eligible patients, n=50 Observed PVCs, n=66	<b>Final sample, n=2032</b> - Neonatal, n=484 - Paediatric, n=1548		<b>RNs baseline, 2009-2010</b> Total sample, n=153 Not eligible, n=2 Received the Q, n=151 Non respondents, n=47 Final sample, n=104 (68.9%)
<b>Post-intervention II, 2010</b> No of patients n= 181 Eligible patients, n=37 Observed PVCs, n=45		<b>Intervention, 2011</b> Reminders activated in the EPR at the intervention units	
		<b>PVCs post-intervention, 2011</b> Total sample, n=1213 Incomplete documentation, n=595 Final sample, n=618 PVCs	<b>PVCs post-intervention, 2011-2012</b> Total sample, n=1213 Incomplete documentation, n=539 Final sample, n=674 PVCs
		<b>RNs post-intervention, 2011</b> Total sample, n=164 Not eligible, n=5 Received the Q, n=159 Non respondents, n=53 Final sample, n=106 (66.7%)	<b>RNs post-intervention, 2011</b> Total sample, n=140 Not eligible, n=8 Received the Q, n=132 Non respondents, n=30 Final sample, n=102 (77.3%)

Q, Questionnaire



### **4.3.3 Paper III**

This paper involved all inpatient and outpatient units at the paediatric hospital. Units with the same Nurse Manager were considered as one unit, resulting in 26 included units. Units that admitted both paediatric and adult patients (one intensive care unit) and units where the RNs did not handle PVCs (two outpatient units) were excluded, which resulted in a final sample of 23 units. The total population of RNs was 886 RNs (Table 5). Exclusion criteria were if they only performed administrative duties, were on parental leave, sick leave or studied full time during the data collection period (n=179), worked on units that also admitted adult patients (n=27) or reported that they did not manage PVCs (n=41). The questionnaire was sent out to 639 RNs and 266 were non-respondents, resulting in a final sample of 373 RNs (58.4% response rate). The median number of respondents per unit was 18 RNs (range 4–27).

### **4.3.4 Paper IV**

The inclusion and exclusion criteria for units for the cluster randomised study, were the same as for paper II, resulting in a final sample of 12 units. One unit in the intervention group changed to another EPR system 60 days after the introduction of the reminder. This unit was therefore only included for 60 days post-intervention and, consequently, also 60 days at baseline.

#### ***4.3.4.1 Sample size calculation and randomisation***

In a record review in 2009 performed at 14 inpatient units at the paediatric hospital, we found 87 PVCs in 147 patients, which yielded an expected number of 6 PVCs on each unit during five days. The proportion of documented PVC-related complications in the EPR, discovered during the record review, were 34%. The record review indicated that it was appropriate to split participating units in two strata based on the expected prevalence of PVCs. Eight units (surgery, cardiology, orthopaedic, neurology, two infection units, advanced homecare and neonatal intensive care unit) were in the strata of high occurrence of PVCs, while four units (oncology, haematology and two neonatal units) were in the strata of lower occurrence. An expected decrease of complications for the intervention units was set at 6-10% based on findings from systematic reviews [57].

A sample size calculation was performed to estimate the number of documented PVCs required [110]. The sample size of 1213 PVCs, about 100 PVCs per unit, was calculated to be necessary to have 80% power to detect a difference in complications of OR=1.5 between control and intervention groups at a significance level of 5% and an intra-cluster coefficient of 0.001 on unit level. The results from paper I that a majority of the observed PVC-related complications were not documented in the EPR, led to that a total of 1213 PVCs from the EPR were to be included in each group at both baseline and post-intervention in order to secure power. The cluster randomisation was carried out by a third person through a simple

draw of lots from each of the strata, allocating six units to the control and intervention groups, respectively.

Data on the primary outcome variable was retrieved from EPRs retrospectively at baseline and prospectively post-intervention. Each PVC was counted as one case and the PVCs should have been inserted and documented in the PVC template at any of the twelve units at baseline (before the 11th of January 2011, the introduction of the computer reminders) and post-intervention (after the 1st of April 2011). PVCs with no complete documentation of reason for removal were excluded (Table 5), resulting in a final sample of 626 PVCs in the intervention group at baseline and 618 post-intervention and 724 PVCs at baseline for the control group and 674 post-intervention.

The secondary outcome was RNs' self-reported adherence to the PVC guideline. The inclusion criteria for RNs were that they worked at one of the 12 units at the time for data collection (Table 5). The exclusion criteria were the same as for paper III, excluding 4 RNs at baseline and 13 RNs post-intervention, which resulted in that 324 RNs received the questionnaire at baseline and 291 post-intervention. The final sample of RNs at baseline was 212 (65.4% response rate) and 208 RNs (71.5% response rate) post-intervention. The mean number of respondents per unit was 17 RNs in both groups and the percentage of RNs responding at the intervention and control units ranged from 55–72% and 53–89% respectively.

#### **4.4 DATA COLLECTION AND ANALYSIS**

Data was collected through observations of patients with PVCs and eventual signs and symptoms of PVC-related complications (paper I), audit of the EPR (papers I, II, IV) and through questionnaires to RNs (papers III, IV).

Categorical data is presented as frequency counts and percentage. Symmetrically distributed data is presented as mean and standard deviation. Asymmetrically distributed data is presented as median and range. Data was analysed using the Statistical Package for the Social Sciences (SPSS) statistical software version 15.0, 16.0 and 20.0 (SPSS Inc., Chicago, IL, USA) as well as Stata version 13 (StataCorp LP, College Station, TX, USA) and SAS PROC GLIMMIX.

#### **4.4.1 Paper I**

Data constituted of observations of patients with PVCs and audit of EPRs.

##### **4.4.1.1 Data collection**

###### *Observations of patients with PVCs*

The observations of patients with PVCs were performed using a protocol that had previously had been used for observations of adult patients with PVCs [111]. The protocol consisted of six main sections: patient data, PVC, outer dressing, inner dressing, three-way stopcock with or without extension tube or needle-free access devices and signs and symptoms of PVC-related complications. Paper I focused on 23 items concerning patient data (three items), PVC (eight items) and signs or symptoms of complications (12 items). One data collector performed the observations and audit of EPRs at baseline and another data collector joined for the post-intervention observations and the audit of EPRs. The data collectors were RNs who had a good knowledge and experience of PVCs and paediatric care.

###### *Audit of the EPRs*

All parts of the EPRs were audited using a protocol based on the protocol for the observations of PVCs. The protocol was divided into six main sections: patient data, PVC, outer dressing, inner dressing, three-way stopcock/needle-free devices/closing cap and signs and symptoms of complications. This paper focused on 17 items concerning patient data, PVC and signs and symptoms of PVC-related complications. All participants' EPRs were audited retrospectively from the approximate date of insertion (the exact date was not always documented) to the documented day of removal. If removal was not documented, the patient record was audited from the date of data collection and two weeks ahead.

##### **4.4.1.2 Data analysis**

To detect differences in categorical variables between the data collection occasions, the chi-square test or Fisher's exact test were applied (baseline vs. post-intervention I, post-intervention I vs. post-intervention II and baseline vs. post-intervention II). Statistical significance was set at  $p < 0.05$ .

#### **4.4.2 Paper II**

Data concerning PVCs, reasons for removal and patient characteristics were based on the data collection performed for paper IV, where baseline and post-intervention data for the cluster randomised study was collected from EPRs.

#### **4.4.2.1 Data collection**

Data on PVCs and patient demographics (age, sex, admission type, and length of stay) were collected from EPRs with support from the County Council's IT/EPR administration. Data concerning PVC-related complications, insertion date, size, site and side and removal date was derived from the PVC template. The PVC template included eight different dropdown options for removal of PVCs (Table 4). When the removal cause "other reasons for removal" was used but an explanatory text was missing, records were manually reviewed for more detailed information. Data concerning patient's date of birth, gender, admission type as well as discharge date were extracted from the EPR system for all participants that had one or several PVCs documented in the template. Incomplete data were manually searched for in the EPR.

#### **4.4.2.2 Data Analysis**

Altogether, nine groups of reasons for removal were included. Reasons due to PVC-related complications were; infiltration, occlusion, signs and symptoms of thrombophlebitis, suspicion of infection or wound. Elective reasons were; completed treatment, PVCs accidentally removed, re-sited PVC in connection with blood sampling or change to central venous access device or other reasons. Subgroup analyses of neonatal and paediatric patients were undertaken to compare complications between these subsets of participants.

PVC dwell time was counted in days. PVC survival time was defined as the interval between PVC insertion date and removal date due to complication. The PVC survival function was estimated by the Kaplan-Meier method. The event in the calculations was the reason for the removal of the PVCs due to complications and removal due to other reasons were censored at the time of PVC removal. Differences in PVC survival time between paediatric and neonatal units were compared by the log-rank test.

The reasons for removal rate per 1000 PVC days was calculated as the sum of PVCs removed divided by the number of PVC days multiplied by 1000. Differences in incidence rates were tested using Poisson regression for individual-level data with PVC days as exposure.

Potential factors (PVC characteristics and patient demographics) associated with the two most common complications found in paper II (infiltration and occlusion) leading to removal of the PVC were explored using simple and multiple logistic regression analyses for paediatric and neonatal patients, respectively. Few PVCs were of size 18 gauge (n= 5), which is why these PVCs were merged with PVCs of size 20 gauge in the analyses. PVCs inserted in the groin (n = 3) or neck (n= 1) were excluded from the analyses due to the small numbers. The variable length of stay and type of admission were excluded in the regression analyses due to multicollinearity. The reference groups for the simple and multiple regression analyses were as follow; sex (female), insertion time (morning), PVC size (18/20 gauge), PVC side

(right), and PVC site (hand). All variables with a p-value < 0.05 in the simple analyses were introduced in the multiple regression analyses.

#### **4.4.3 Paper III**

Data was collected through a questionnaire and the data collection period stretched from October 2009 to January 2010.

##### **4.4.3.1 Data collection**

The questionnaire consisted of 104 items divided into five main sections: management of venous catheters (central and peripheral), work context, sources of knowledge, research utilization and RNs' characteristics. Paper III focused on the sections concerning RNs' management of PVCs (6 items), work context (59 items) and RNs' characteristics (13 items).

The questionnaire was placed in the RNs' mailboxes throughout the hospital. A cover letter providing information about the study and a prepaid envelope addressed to a registration bureau accompanied the questionnaire. In addition, all RNs received an e-mail informing them about the study. Three rounds of reminders were distributed via e-mail to non-responders.

##### *Management of PVCs*

Data concerning RNs management of PVCs were collected through six items based on recommendations from the hospitals CPG. The items were answered on a 5-point Likert scale with the following response options: *never, rarely, occasionally, frequently, and always*. Three of the items were selected because adherence to them was presumed to have the greatest impact on patients with PVCs [112]: *How often do you disinfect your hands with alcohol-based products before managing PVCs? How often do you use disposable gloves when managing PVCs? How often do you perform daily inspection of PVCs' insertion sites?* One item addressed whether the RNs knew about the hospital's CPGs for venous catheters in paediatric care, with the response alternatives yes and no.

##### *Work context*

Work context was measured with the ACT, conceptually framed by the PARIHS framework, and designed to assess context within complex healthcare settings [53]. The ACT consist of 59 items organised into eight dimensions measuring organisational context: (1) leadership, reflecting emotionally intelligent leadership; (2) culture, reflecting a supportive work culture; (3) evaluation, the use of data to assess the unit's performance (e.g., infection rates); (4) information sharing interactions, informal exchanges between individuals working in a unit that can promote the transfer of knowledge; (5) information sharing activities, formal exchanges that occur between individuals in a unit through scheduled activities that can

promote the transfer of knowledge; (6) information sharing social processes, active connections among people that reflect trust, mutual understanding, and shared values and behaviours; (7) structural and electronic resources, material and structure features that facilitate the ability to access and use knowledge; and (8) organisational slack, representing the three sub-concepts; staff, space, and time, which reflect buffering mechanisms in the work-flow process.

The ACT dimensions 1, 2, 3, 6, and 8 were answered on a five-point Likert scale with the response alternatives *strongly disagree*, *disagree*, *neither agree nor disagree*, *agree*, and *strongly agree*. Dimensions 4, 5, and 7 were answered on a five-point Likert frequency scale with the possible responses *never*, *rarely*, *occasionally*, *frequently*, and *almost always*. Common for all dimensions was that a higher score indicated a more positive or a stronger work context.

The ACT used in this thesis has been modified specifically for paediatric acute care settings [113]. Permission to use the translated Swedish ACT version was granted by the developers. The ACT has been pilot tested in Swedish hospital settings, showing acceptable reliability (Cronbach's  $\alpha$  0.59 - 0.88) and acceptable properties regarding validity [114]. For the study presented in paper III, Cronbach's  $\alpha$  for the eight dimensions ranged between 0.74 and 0.90, except for information sharing activities, structural and electronic resources, and organisational slack (space), for which Cronbach's  $\alpha$  ranged between 0.59 and 0.71.

#### *RNs characteristics*

The section on RNs' characteristics included 13 items: RNs' educational level (basic–advanced), years since receiving the nursing certificate, participation in research activities (yes–no), employment (full time–part time), age (years), and gender.

#### **4.4.3.2 Data analysis**

To analyse the relationship between individual or context characteristics and GPG adherence, a first set of logistic regression analyses (simple and multiple) was performed using work context dimensions and demographics as independent variables and adherence to the CPG recommendations as dependent variables.

#### *Dependent variables*

The scorings from RNs' self-reported adherence to the three CPG recommendations (disinfection, usage of disposable gloves and inspection) were dichotomized into *always* versus *not always* (the latter representing the response alternatives never, rarely, occasionally, and frequently).

### *Independent variables*

The ACT dimensions using a five-point Likert agreement scale were scored from 1 (strongly disagree) to 5 (strongly agree) and analysed by calculating the mean of each dimension. For the dimensions using a five-point Likert frequency scale (information sharing interactions, information sharing activities, and structural and electronic resources) scoring was transformed as follows: never and rarely=0, occasionally=0.5, frequently and always=1. Responses were then analysed by calculating the total sum for each dimension. The ACT dimension mean scores per units were calculated by adding the dimension sum scores of RNs at each unit and then dividing by the number of RNs at the unit.

The background variables of age, highest level of education, participation in research activities, and employment were dichotomized into 37 years or younger versus older than 37 years (37 years was the median age), basic education (certificate or bachelor's) versus advanced (1-year master or specialist post-registration qualification), participated versus did not participate in research, part-time versus full-time work and knowledge about the CPGs for venous catheters versus no knowledge of the CPGs. The number of years since each respondent had completed the nursing certificate was treated as a continuous variable.

The variables that were significant ( $p < 0.05$ ) in the simple logistic analyses were included in the multiple logistic regression analyses. An additional set of multilevel regression was performed to adjust for the correlation within the clinical unit with respect to the outcome variables. The data were analysed in both simple and multiple logistic regression models, and type 3 test analyses were used to evaluate the statistical significance of each variable included in the statistical model. The final logistic regression model was derived using backward elimination.

One-way ANOVA (analysis of variance) was used to test for differences between units regarding dimensions of context. Intraclass correlation (ICC) analysis was conducted to examine to what extent the variation in scorings depended on respondents' were being nested in units.

#### **4.4.4 Paper IV**

The data collection period for PVC-related complications in order to reach sufficient power stretched from December 2009 to December 2010 at baseline and from April 2011 to January 2012 post-intervention (Table 5). Data on RNs' adherence to the CPG and their perceived work context were collected through the same questionnaire used in paper III. The data collection for RNs at baseline was the same as for paper III, stretching from October 2009 to January 2010, while the post-intervention data collection was from May to September 2011 (Table 5).

#### **4.4.4.1 Data collection**

##### *PVCs, related complications and patients*

Data concerning PVCs and patient demographics were collected in the same manner as in paper II.

##### *RNs' adherence and context*

Data concerning RNs' adherence and work context were measured with the same questionnaire as used in paper III. Four rounds of reminders were distributed via e-mail to non-responders at baseline and three rounds post-intervention.

#### **4.4.4.2 Data analysis**

##### *PVC-related complications*

Documented reasons for PVCs removal due to complications comprised: infiltration including extravasation, occlusion, signs and symptoms of thrombophlebitis, suspicion of infection, wounds and PVCs accidentally removed. Exact 95% confidence interval for proportions based on the binomial distribution are provided. Differences between intervention and control groups from baseline to post-intervention in reasons for removals of PVCs were analysed using logistic regression analysis.

An interaction effect of being in the intervention group post-intervention was used for assessing the intervention effect. A result of an increased adherence to the CPG could have been an increased number of PVC days; thus the difference of PVC mean days from baseline to post-intervention was analysed using linear regression.

##### *Adherence*

RNs' adherence to the CPG were measured and treated in the same manner as for paper III. Statistical analysis of intervention effect on RNs' self reported adherence was done as for analysis of PVC-related complications.

##### *Context*

This paper focused on the three dimensions of context defined by the PARIHS framework, namely leadership, culture and evaluation. These variables were treated in the same manner as for paper III.

The cut-off to categorise RNs contextual dimension mean scores from the baseline measurement was:  $> 3.5$  were categorised as high and  $\leq 3.5$  as low [38, 40, 115]. Data were grouped using the mean score of each individual on the three contextual dimensions. RNs



total context scores were also used to allocate them into four context groups; high context, which represented high scores on all three context dimensions; moderately high context, high score on two dimensions and a low score on one; moderately low context, high score on one dimension and low on the two remaining; and low context, low score on all three context dimensions. The number of RNs per context group were calculated and then divided into intervention or control group. Fischer's exact test was applied between the four context groups and intervention and control units and statistical significance was set at  $p < 0.05$ .

An overview of the statistical methods used in papers I-IV is shown in Table 6.

**Table 6.** Overview of the statistical methods included in the thesis

Method	Paper I	Paper II	Paper III	Paper IV
Descriptive	x	x	x	x
Cohen's kappa	x			
Chi-square test	x			
Fisher's exact test	x			x
Kaplan-Meier method		x		
Log-rank test		x		
Poisson regression		x		
Simple and multiple logistic regression analyses		x	x	x
Multilevel logistic regression analysis			x	
One-way ANOVA			x	
Intraclass correlation (ICC)			x	
Linear regression				x

## 5 ETHICAL CONSIDERATIONS

Approval to conduct the two studies was granted by the head of the paediatric hospital and by the Regional Ethics Review Board in Uppsala (No.2008/107 and 2008/360).

Patients and their carers, in the first study (paper I) were informed both verbally and in writing about the study and asked for consent for the observation and record audit. Before asking patients or family members concerning participation in the study, discussions with RNs working at the units concerning the patients' situation and care were carried out. Some patients were too sick or the situation was just not right to ask for participation in the study. The observations did not cause patients any harm or discomfort and the participants were informed both verbally and in writing that they could withdraw from the study at any time. When signs and symptoms of complications were observed RNs were not informed, as it could affect their documentation.

The collection of data on PVCs and patients from the EPR system in the second study (papers II-IV) was also granted by each department chairman at the paediatric hospital. The data collection focused on characteristics of PVCs and reasons for removal, while patient data focused on gender, age and reason for admission. Data concerning documentation was summarised at a unit level and never on an individual level.

A letter to RNs that clarified the confidential handling of the research data and the voluntary nature of participation accompanied the questionnaire. Informed consent was assumed through the return of the questionnaire. An independent registration bureau received and registered the RNs answers.

## 6 FINDINGS

This section presents the main findings from the papers presented in this thesis; Accuracy and completeness in PVC documentation (paper I); PVCs, dwell time, reasons for removal and factors associated with PVC-related complications (paper II); RNs' adherence and work context (paper III); and, effects of the computer reminders (paper IV).

### 6.1 ACCURACY AND COMPLETENESS IN PVC DOCUMENTATION (PAPER I)

A significant increase in PVCs with complete documentation and documentation of removal was observed post-intervention, i.e. after the introduction of the PVC template, compared to baseline (Table 7). The documentation of PVC insertion did not improve, but there was an increase in the documentation of size and side post-intervention. The percentage of PVCs with documentation of any kind was relatively stable (85-93%). One of the 22 signs and symptoms of complications observed before the intervention was documented in the EPR and none of the complications (n=17 and n=9) post-intervention.

**Table 7.** Documentation of PVC in the EPR at baseline and post-intervention

	Baseline n=65 n (%)	Post-intervention I n=66 n (%)	Post-intervention II n=45 n (%)	P-value <sup>a</sup>
Insertion date	50 (77)	44 (67)	34 (76)	0.868
Size	26 (40)	31 (47)	28 (62)	0.022
Side	41 (63)	46 (70)	39 (87)	0.006
Site	52 (80)	50 (76)	42 (93)	0.051
Insertion (Date, size, side & site)	20 (31)	21 (32)	22 (49)	0.054
Removal (Date, size, side & site)	0 (-)	5 (8)	4 (9)	0.026
Complete documentation (Date, size, side & site at insertion & removal)	0 (-)	5 (8)	4 (9)	0.026
Any kind (Insertion date, size, side, site or removal date)	59 (91)	56 (85)	42 (93)	0.735

<sup>a</sup> Chi-square test or Fisher's exact test was performed for baseline vs. post-intervention II.

### 6.2 PVCS, DWELL TIME, REASONS FOR REMOVAL AND FACTORS ASSOCIATED WITH PVC-RELATED COMPLICATIONS (PAPER II)

#### 6.2.1 Characteristics of PVCs

For the 2032 PVCs included, the median time for PVC *in situ* was 2 days (range 1-14). The PVC sizes most frequently inserted were 0.7 mm/24 gauge (51.9%) followed by the smaller

size, 0.6mm/26 gauge (25.1%). The most common PVC sites were on the hand (39.3%) or in the bend of the arm (34.3%). The PVCs were equally inserted on the left or the right side of the body and most PVCs (40.9%) were inserted during evening shifts (Table 8).

**Table 8.** Characteristics of documented PVCs/patients in paediatric and neonatal units

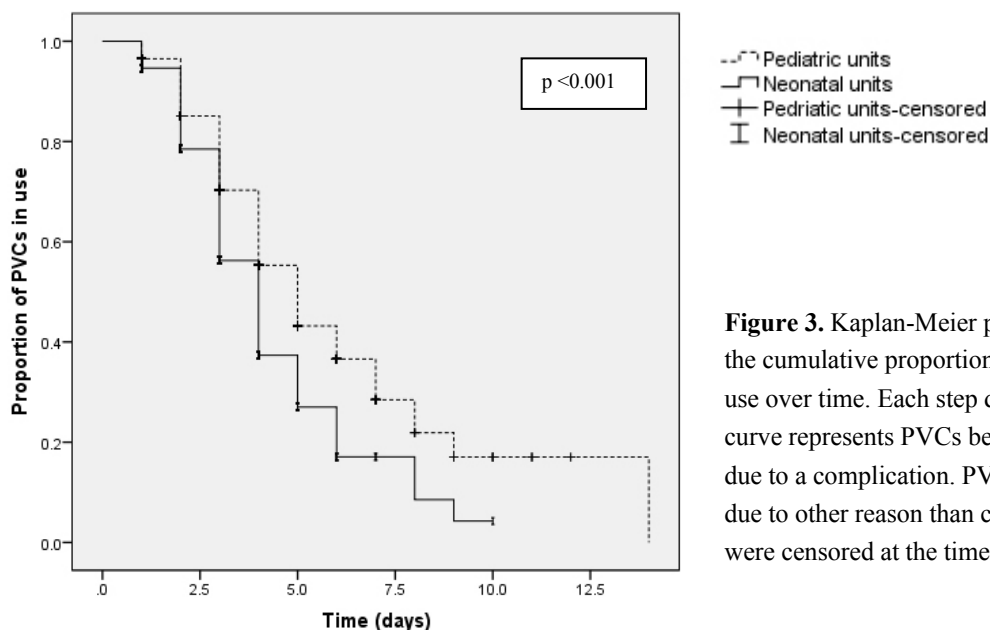
	Total sample n=2032	Paediatric units n=1548	Neonatal units n=484
<b>Patients</b>			
Median age (range)	1 year (0.0-18)	4 years (0.0-18)	2 days (1-78)
Sex, n (%)			
Male	1140 (56.1)	862 (55.7)	278 (57.4)
Female	892 (43.9)	686 (44.3)	206 (42.6)
Median length of stay, days (range)	4 (1-255)	3 (1-255)	12 (1-194)
Type of admission, n (%)			
Acute	1475 (72.6)	991 (64.0)	484 (100)
Elective	557 (27.4)	557 (36.0)	
<b>PVS</b>			
PVC <i>in situ</i> , median days (range)	2 (1-14)	2 (1-14)	3 (1-10)
Time for insertion (%)			
Morning (07.01 – 14.00)	652 (32.1)	537 (34.7)	115 (23.8)
Evening (14.01 – 21.00)	832 (40.9)	644 (41.6)	188 (38.8)
Night (21.01 – 07.00)	548 (27.0)	367 (23.7)	181 (37.4)
Size, n (%) <sup>a</sup>			
26 gauge	509 (25.1)	342 (22.1)	167 (34.6)
24 gauge	1053 (51.9)	738 (47.7)	315 (65.4)
22 gauge	418 (20.6)	418 (27.0)	0 -
20 gauge	44 (2.2)	44 (2.8)	0 -
18 gauge	5 (0.2)	5 (0.3)	0 -
Side, n (%) <sup>b</sup>			
Right	1017 (50.1)	770 (49.8)	247 (51.1)
Left	1013 (49.9)	777 (50.2)	236 (48.9)
Site, n (%) <sup>c</sup>			
Hand	799 (39.3)	573 (37.0)	226 (46.7)
Wrist	60 (3.0)	40 (2.6)	20 (4.1)
Forearm	42 (2.1)	33 (2.1)	9 (1.9)
Bend of arm	697 (34.3)	652 (42.1)	45 (9.3)
Foot	252 (12.4)	163 (10.5)	89 (18.4)
Ankle	54 (2.7)	21 (1.4)	33 (6.8)
Scalp	123 (6.1)	61 (3.9)	62 (12.8)
Groin	3 (0.1)	3 (0.2)	0 -
Neck	1 (0.05)	1 (0.1)	0 -

<sup>a</sup> internal attrition n=3, <sup>b</sup> internal attrition n=2, <sup>c</sup> internal attrition n=1

## 6.2.2 Dwell time

Figure 3 presents the Kaplan-Meier plot showing the cumulative proportion of PVCs in use, representing n=1548 PVCs in patients whom were admitted to paediatric units and n=484 to neonatal units. The estimated median PVC survival time until removal due to complication was five days (95% CI 4.74-5.26). There was a statistically significant difference in survival

time between PVCs in patients at the paediatric (five days, 95% CI 4.63-5.37) and the neonatal units (four days, 95% CI 3.70-4.30,  $p < 0.001$ ).



**Figure 3.** Kaplan-Meier plot showing the cumulative proportion of PVCs in use over time. Each step down at the curve represents PVCs being removed due to a complication. PVCs removed due to other reason than complication were censored at the time of removal.

### 6.2.3 Reasons for removal

The majority of the PVCs (59.8%) remained in place until therapy was completed (Table 9). A few PVCs (0.7%) without complications were re-sited in connection with blood sampling or removed because of a need for a central venous access device. In the total sample, 719 (35.4%) PVCs (127.3 per 1000 catheter days) were removed due to complications. The most common complications leading to removal were infiltration and occlusion (Table 9). Patients admitted to neonatal units were more affected by infiltrations compared to patients at the paediatric units ( $p < 0.001$ ).

### 6.2.4 Factors associated with PVC-related complications

#### 6.2.4.1 Infiltration

In simple logistic regression analyses for neonatal patients, PVCs inserted at night time (OR 1.80, 95% CI 1.02 – 3.16) and younger age (OR 0.97, 95% CI 0.94 – 1.00) were factors statistically related to the likelihood of PVC removal due to infiltration. In the multiple analyses younger age (OR 0.97 95% CI 0.94 – 1.00) remained associated with PVC removal due to infiltration.

Factors identified in simple logistic regression analyses associated with infiltration in paediatric patients were younger age (OR 0.96, 95% CI 0.93 – 0.99) and insertion of PVCs in the ankle (OR 3.20, 95% CI 1.13 – 9.09). In the multiple logistic regression analyses, younger age (OR 0.96, 95% CI 0.92 – 0.99) and PVCs inserted in the bend of the arm (OR 1.48, 95%

CI 1.00 – 2.20) or the ankle (OR 2.81, 95% CI 0.98 – 8.02) were found independently related to the likelihood that the PVC would be removed due to infiltration.

**Table 9.** Documented reasons for removal of PVC and comparison between paediatric and neonatal units

Reasons for removal	Total sample n=2032		Paediatric units n=1548		Neonatal units n=484		Comparison, paediatric and neonatal units
	n (%)	per 1000 catheter days	n (%)	per 1000 catheter days	n (%)	per 1000 catheter days	p-value per 1000 catheter days
<b>Removal due to complications</b>							
Infiltration including extravasation	293 (14.4)	51.9	165 (10.7)	38.7	128 (26.4)	92.8	<0.001
Occlusion	273 (13.4)	48.4	201 (13.0)	47.1	72 (14.9)	52.2	0.45
Signs and symptoms of thrombophlebitis	142 (7.0)	25.2	109 (7.0)	25.5	33 (6.8)	23.9	0.74
Suspicion of infection	6 (0.3)	1.1	3 (0.2)	0.7	3 (0.6)	2.2	0.17
Wound at insertion site	5 (0.2)	0.9	2 (0.1)	0.5	3 (0.6)	2.2	0.04
Total	719 (35.4)	127.3	480 (31.0)	112.5	239 (49.4)	173.3	
<b>Elective reasons for removal</b>							
Completed treatment	1215 (59.8)	215.2	993 (64.1)	232.7	222 (45.9)	161.0	<0.001
PVC accidentally removed	64 (3.1)	11.3	46 (3.0)	10.8	18 (3.7)	13.1	0.49
Other reason <sup>a</sup>	20 (1.0)	3.5	17 (1.1)	4.0	3 (0.6)	2.2	0.33
Re-sited PVC <sup>b</sup>	14 (0.7)	2.5	12 (0.8)	2.8	2 (0.4)	1.5	0.39
Total	1313 (64.6)	232.6	1068 (69.0)	250.3	245 (50.6)	177.7	

<sup>a</sup> E.g. the patient is bothered by the PVC or location dependent

<sup>b</sup> Re-sited PVC in connection with blood sampling or change to central venous access device

#### 6.2.4.2 Occlusion

Simple logistic regression analyses in neonatal patients showed that longer PVC *in situ* time (OR 1.22, 95% CI 1.03 – 1.45) and PVCs inserted in the foot (OR 3.05, 95% CI 1.59 – 5.85) or ankle (OR 4.03, 95% CI 1.70 – 9.56) were significantly related to PVC removal due to occlusion. In the multiple analyses were longer PVC *in situ* time (OR 1.32, 95% CI 1.09 – 1.58) and PVCs inserted in the foot (OR 3.47, 95% CI 1.78 – 6.79) or ankle (OR 5.00, 95% CI 2.06 – 12.15) associated with PVC removal because of occlusion.

In paediatric patients were younger age (OR 0.92, 95% CI 0.89 – 0.95), longer PVC *in situ* time (OR 1.21, 95% CI 1.12 – 1.31), PVCs inserted during the evening shift (OR 1.44, 95% CI 1.01 – 2.05), PVC size 26 gauge (OR 3.53, 95% CI 1.06 – 11.7) and PVCs inserted in the

bend of the arm (OR 0.63, 95% CI 0.44 – 0.91), foot (OR 2.15, 95% CI 1.39 – 3.33), ankle (OR 3.43, 95% CI 1.34 – 8.77) or scalp (OR 2.44, 95% CI 1.31 – 4.53) significantly related to PVC removed due to occlusion. In the multiple analyses were longer PVC *in situ* time (OR 1.22, 95% CI 1.12 – 1.33) and PVCs inserted in the foot (OR 1.99, 95% CI 1.26 – 3.14), ankle (OR 3.51, 95% CI 1.34 – 9.24) or scalp (OR 2.07, 95% CI 1.07 – 3.97) independently related to the likelihood that the PVC would be removed due to occlusion.

## 6.3 RNS' ADHERENCE AND WORK CONTEXT (PAPER III)

### 6.3.1 Adherence

Of the 373 RNs who answered the questionnaire, 227 (60.9%) stated that they knew about the CPGs for venous catheter in paediatric care. On an individual level, RNs' complete adherence (answering “always”) to the three CPG recommendations varied between 53% for daily inspection to 91% for disinfection of hands (Table 10). At unit level, complete adherence ranged from zero units for daily inspection to 11 units for disinfection of hands. At two units all RNs had complete adherence to use of disposable gloves.

The Intraclass correlation analyses underlined the variation between units in scoring of the adherence to the CPG recommendations, most pronounced for disinfection of hands (0.19), followed by daily inspection of PVCs' insertion sites (0.09) and usage of disposable gloves (0.07).

**Table 10.** RNs' adherence to the CPG recommendations for RNs individually and aggregated to unit levels

Individuals, n = 373 <sup>a</sup>	Missing	Never	Seldom	Sometimes	Often	Always
Disinfection, n (%)	4 (1)	-	2 (0)	4 (1)	25 (7)	338 (91)
Disposable gloves, n (%)	9 (2)	6 (1.5)	17 (4.5)	32 (9)	71 (19)	238 (64)
Daily inspection, n (%)	35 (9)	7 (2)	7 (2)	23 (6)	103 (28)	198 (53)
Units, n = 23 <sup>b</sup>	< 50%	50 - 69%	70 - 89%	90 - 99%	100%	
Disinfection	-	1	7	4	11	
Disposable gloves	6	8	6	1	2	
Daily inspection <sup>c</sup>	7	9	3	3	0	

<sup>a</sup> Individuals are categorised according to the response alternatives to this item. <sup>b</sup> Units are categorised based on the percentage of RNs' that reported complete adherence (answered always). <sup>c</sup> At one unit none of the RNs answered the item regarding daily inspection of PVCs' insertion sites.

### 6.3.2 Context

RNs' mean scores and standard deviations for the dimensions measuring work context for all RNs individually and aggregated to unit level are presented in Table 11. For the dimensions

calculated as means, RNs scored highest in their rating of information sharing social processes, followed by culture and leadership, while organisational slack (space) was scored lowest. The ANOVA analyses point to significant differences between units in the mean scores of each context variable except information sharing interactions. The Intraclass correlation analyses underlined the variation between units in scorings of the contextual variables, most accentuated for leadership, evaluation, and organisational slack.

**Table 11.** Summary of context data for RNs individually and aggregated to unit level

Dimensions of context	No items	Scale	Individuals n=373	Units n=23	ANOVA <sup>b</sup>		
			Mean (SD)	Mean (SD)	F-statistic	p value	ICC
1. Leadership	6	1–5	3.5 (0.8)	3.5 (0.5)	7.392	0.000	0.30
2. Culture	6	1–5	3.8 (0.6)	3.8 (0.3)	3.367	0.000	0.12
3. Evaluation	6	1–5	3.0 (0.8)	3.0 (0.4)	4.415	0.000	0.19
4. Information sharing interactions <sup>a</sup>	7	0–7	3.1 (1.1)	3.1 (0.3)	1.416	0.10	0.03
5. Information sharing activities <sup>a</sup>	5	0–5	3.3 (1.2)	3.2 (0.5)	2.497	0.000	0.10
6. Information sharing social processes	6	1–5	3.9 (0.5)	3.9 (0.2)	2.345	0.001	0.08
7. Structural and electronic resources <sup>a</sup>	11	0–11	5.1 (2.0)	5.3 (0.8)	1.833	0.014	0.05
8. Organisational slack – Staffing	2	1–5	3.1 (1.2)	3.1(0.7)	6.813	0.000	0.26
Organisational slack – Space	4	1–5	2.7 (0.9)	2.6 (0.5)	4.278	0.000	0.19
Organisational slack – Time	6	1–5	3.1 (0.6)	3.0 (0.3)	4.595	0.000	0.20

<sup>a</sup> Variables that were first calculated as total sum of items; mean values of these sums were then analysed. <sup>b</sup> ANOVA, analysis of variance, was applied to mean values at unit level. SD, standard deviation. ICC, Intraclass correlation.

### 6.3.3 Relationship between adherence and context

Because of the variation at unit level in adherence to the three CPG recommendations for PVC management we applied two approaches; multiple versus multilevel logistic regression analyses. These two approaches generated similar but not identical findings. In the multiple logistic regression analyses, we estimated the following variables to have a significant association to adherence to the guideline recommendations: increase in the use of structural and electronic resources (OR 1.32, 95% CI 1.06 – 1.64) with disinfection of hands, meaning that each one unit increase in the RNs' responses in the coded categories (0, 0.5, 1) for structural and electronic resources resulted in a 32% increase in the likelihood that RNs reported adherence to disinfecting of hands. Structural and electronic resources also had a significant association with daily inspection of PVC insertion site (OR 1.20, 95% CI 1.05 – 1.37). Fewer years since nursing certificate (OR 0.97, 95% CI 0.94 – 0.99) was significantly related with use of disposable gloves, meaning that each nursing year resulted in a 3% decrease in the likelihood that RNs reported adherence to the usage of disposable gloves. In the multilevel logistic regression analyses, we identified an increase in the coded



categories for structural and electronic resources (OR 1.31, 95% CI 1.03 – 1.68) as significantly related to disinfection of hands, higher scores in the coded categories for participation in information sharing activities (OR 1.17, 95% CI 1.00 – 1.38) and fewer years since nursing certificate (OR 0.96, 95% CI 0.93 – 0.99) as significantly related to the use of disposable gloves. Regular evaluation (OR 1.45, 95% CI 1.01 – 2.08) was significantly related to daily inspection of PVCs' insertion sites, meaning that each increase on the evaluation scale resulted in a 45% increase in the likelihood that RNs reported adherence to daily inspection of insertion sites.

## 6.4 EFFECTS OF THE COMPUTER REMINDERS (PAPER IV)

### 6.4.1 PVC-related complications

The overall number of documented complications at all units at baseline was 546 (40.4%) and 575 (44.5%) post-intervention. The number of complications at the intervention units was 254 (40.6%) at baseline and 259 (41.9%) post-intervention and 292 (40.3%) at baseline at the control units and 316 (46.9%) post-intervention (Table 12). The logistic regression analysis regarding change in complication rates did not show any significant effect of the computer reminders ( $p=0.18$ , 95% CI -12.8% to + 2.3%) from baseline to post-intervention between the groups. There was no significant difference in mean PVC days from baseline to post-intervention between the groups. The most frequent complication in the intervention group at baseline and post-intervention was infiltration (17-17%) followed by occlusion (14-15%) and signs and symptoms of thrombophlebitis (6-6%) whereas occlusion (18-18%) followed by infiltration (10-15%) and signs and symptoms of thrombophlebitis (8-10%) was most frequent in the control group.

**Table 12.** Number of documented complications and difference in complication rate between baseline and post-intervention for the intervention and control units

Intervention units				Control units			
No of complications				No of complications			
Baseline	Post-intervention	Difference in complication rate		Baseline	Post-intervention	Difference in complication rate	
n (%)	n (%)	%		n (%)	n (%)	%	
<b>Total</b>	<b>254 (40.6)</b>	<b>259 (41.9)</b>	<b>+ 1.3</b>	<b>Total</b>	<b>292 (40.3)</b>	<b>316 (46.9)</b>	<b>+ 6.6</b>
Unit 1	0	0	-	Unit 1	22 (61.1)	28 (57.1)	- 4.0
Unit 2	58 (34.3)	42 (31.1)	- 3.2	Unit 2	107 (43.7)	111 (43.4)	- 0.3
Unit 3	41 (25.0)	74 (33.5)	+ 8.5	Unit 3	28 (26.4)	42 (37.2)	+ 10.8
Unit 4	6 (42.9)	5 (38.5)	- 4.4	Unit 4	76 (39.8)	85 (56.3)	+ 16.5
Unit 5	21 (53.8)	28 (62.2)	+ 8.4	Unit 5	29 (41.4)	33 (47.1)	+ 5.7
Unit 6	128 (53.6)	110 (53.9)	+ 0.3	Unit 6	30 (39.5)	17 (48.6)	+ 9.1

### 6.4.2 RNs' adherence

RNs median age in the intervention and control group was 36 years and 35 years, respectively, both at baseline and post-intervention (Table 13). A majority of the RNs in the intervention group worked fulltime, while the percentage of RNs that worked fulltime and part time in the control group was almost equally distributed. RNs median years since nursing certificate went down in both groups, as did the median years at the current unit. A majority of RNs in both groups had a basic educational level, though the percentage of RNs with an advanced level was slightly higher and more stable at the intervention units compared to the control units. RNs awareness of the CPGs for venous catheters was stable in the intervention group and a higher percentage of RNs knew of the CPGs post-intervention at the control units (Table 13).

The number of RNs with full adherence (answered always) to disinfection of hands at baseline and post-intervention in the intervention group went from 90% to 89% (n=97/93) and from 93% to 85% (n=96/87) in the control group. The adherence to usage of disposable gloves in the intervention group went from 74% to 72% (n=80/76) and stayed at 69% (n=71/70) for the control group between baseline and post-intervention. The adherence to daily inspection of PVC insertion site went from 54 to 56% (n=58/58) for the intervention group and from 46% to 54% (n=47/55) for the control group.

There was no significant difference regarding RNs' adherence to the CPG recommendations between the groups from baseline to post-intervention: disinfection of hands (OR 2.05, 95% CI 0.57-7.39), usage of disposable gloves (OR 0.96, 95% CI 0.41-2.23), or for daily inspection (OR 0.77, 95% CI 0.35-1.66).

**Table 13.** Background characteristics for RNs at baseline and post-intervention for the intervention and control group

	Intervention group		Control group	
	Baseline (n=108)	Post- intervention (n=106)	Baseline (n=104)	Post- intervention (n=102)
Median age, years (range)	36 (23-59)	36 (22-61)	35 (24-62)	35 (24-62)
Female, n (%)	103 (98)	100 (97)	103 (99)	100 (99)
Median years since nursing certificate (range)	9.0 (1-40)	7.0 (0-40)	7.0 (1-42)	6.0 (0-39)
Median years at current unit (range)	3.1 (0-32)	2.7 (0-15)	3.7 (0-40)	2.0 (0-25)
Employment				
Full-time, n (%)	64 (61)	72 (71)	58 (56)	48 (48)
Part-time, n (%)	41 (39)	30 (29)	46 (44)	52 (51)
Educational level				
Basic, n (%)	53 (52)	56 (54)	62 (60)	67 (66)
Advanced, n (%)	49 (48)	47 (46)	42 (40)	34 (34)
Awareness of the CPGs, n (%)	74 (69)	72 (68)	61 (59)	79 (77)

### 6.4.3 Context

The categorisation of RNs' mean scores into high and low in paper IV was significantly different between the intervention and control group for culture ( $p=0.037$ ), with RNs in the intervention group scoring higher (Table 14). An almost equal distribution of RNs in both groups scored their leadership as high or low while a majority of the RNs scored their culture as high and evaluation as low.

**Table 14.** Context for intervention and control units at baseline

	Intervention units RNs, n (%)	Control units RNs, n (%)	Fischer's exact test p value
<b>Context dimensions</b>	<b>RNs= 108</b>	<b>RNs= 104</b>	
<i>Leadership</i>	104 (96.3)	102 (98)	0.890
Mean (SD)	3.42 (0.75)	3.59 (0.84)	
High <sup>a</sup>	52 (50)	50 (49)	
Low <sup>b</sup>	52 (50)	52 (51)	
<i>Culture</i>	104 (96.3)	103 (99)	0.037
Mean (SD)	3.99 (0.52)	3.78 (0.65)	
High <sup>a</sup>	85 (81.7)	71 (68.9)	
Low <sup>b</sup>	19 (18.3)	32 (31.1)	
<i>Evaluation</i>	105 (96.3)	100 (96.2)	0.759
Mean (SD)	3.09 (0.72)	3.04 (0.90)	
High <sup>a</sup>	29 (27.6)	30 (30.0)	
Low <sup>b</sup>	76 (72.4)	70 (70.0)	
<b>Context groups <sup>c</sup></b>	<b>RNs= 101</b>	<b>RNs= 97</b>	
High context <sup>d</sup>	14 (13.9)	22 (22.7)	
Moderately high context <sup>e</sup>	44 (43.6)	22 (22.7)	
Moderately low context <sup>f</sup>	31 (30.7)	34 (35.1)	
Low context <sup>g</sup>	12 (11.9)	19 (19.6)	

<sup>a</sup> High = individual mean score  $> 3.5$ , <sup>b</sup> Low = individual mean score  $\leq 3.5$ , <sup>c</sup> Significant difference ( $p=0.013$ ) in the distribution of the different context groups between intervention and control units, <sup>d</sup> High scores on all context dimensions, <sup>e</sup> High on two dimension and low on one, <sup>f</sup> High on one dimension and low on two, <sup>g</sup> Low scores on all dimensions. SD, standard deviation

There was a significant difference ( $p=0.013$ ) in the distribution over the four context groups between the intervention and control units. An almost equal number of RNs in both groups scored their context as either high or low. A majority of the RNs in the intervention group scored their context as moderately high followed by moderately low and the pattern for the control group was vice versa.

## 7 DISCUSSION

One aim of this thesis was to evaluate the effects of implementing recommendations from a CPG for PVCs as reminders in EPRs in paediatric care. Another aim was to describe factors of importance for the implementation process and outcomes.

To summarise the main findings, the EPR did not provide accurate and complete data concerning PVCs and related complications either before or after the introduction of a PVC template (paper I). The median time for PVC *in situ* was 2 days and median PVC survival time until removal due to PVC-related complication was five days (paper II). One-third of the patients were affected by a PVC-related complication as documented in the EPR, with infiltration and occlusion occurring most frequently (paper II). RNs' adherence to the three CPG recommendations for PVCs on unit level varied. RNs on half of the units demonstrated complete adherence on disinfection of hands, whereas less than 70% of the RNs at a majority of the units reported complete adherence to the use of disposable gloves and daily inspection of PVC insertion site (paper III). Work context, in the form of structural and electronic resources, information sharing activities and evaluation was in different ways associated with the adherence to the CPG recommendations (paper III). The computer reminders integrated in EPRs did not have any significant effect on PVC-related complications or on RNs' adherence to the CPG recommendations (paper IV). The context in both the intervention and control group was perceived by the RNs as moderately low to moderately high (paper IV).

If the results of an intervention are negative, questions will arise as to whether that intervention was inadequately developed and if results from similar interventions have also been ineffective [36]. Other questions may include whether the intervention was poorly implemented, implemented in an inappropriate context or whether the intervention used an unsuitable design, comparison group and/or outcomes [36]. The following section will discuss the accuracy and completeness of PVC documentation (paper I), PVC-related complications (paper II), the influence of work context (papers III, IV) and the computer reminders (paper IV).

### 7.1 ACCURACY AND COMPLETENESS OF PVC DOCUMENTATION

One of the strengths of this thesis is that the outcome variable documented PVC-related complications (paper IV), was studied in order to investigate the accuracy and completeness of these data in the EPR (paper I). Quality and safety regulators as well as researchers often rely heavily on the notion that patient records accurately reflect the care given as well as patients' outcomes.

A Cochrane review on nursing records over the last 60 years indicate that RNs and other healthcare professionals believe that there should be a link between nursing documentation and the quality of care that patients receive [76]. The authors state that documentation is still

seen as an extra burden and an administrative concern that is not integrated in the care of patients. They further argue that the challenge for nursing is to understand what kind of nursing practice is best served by which documentation system. Basically, what kind of data is best served by structured documentation and what should be written in free text.

The results from paper I showed that the EPR did not provide accurate data on PVCs either before or after the introduction of the PVC template. The documentation of any kind was however relatively stable throughout that study, which is coherent with similar studies [79]. This indicates that RNs seem to have the intention to document PVCs, but that the documentation lacks one or several of the components needed in order to track a PVC in EPRs, namely data on insertion date, side, site and size [105, 108, 109]. By using the PVC template, the RNs automatically documented the minimum information needed, as these were mandatory fields. There was a statistical increase in the complete documentation of PVCs between baseline and post-intervention (paper I), but the increase would be unlikely to have a clinical impact, as only four PVCs had complete documentation post-intervention II. An increase in the number of PVCs with complete documentation followed the number of PVCs with documented reason for removal, meaning that the number of PVCs with complete documentation would most likely increase if the number of PVCs with documented reason for removal increased. More recent published studies have shown the effects of increased accuracy and completeness of nursing documentation have either introduced standardised nursing terminology and/or documentation templates [67, 75, 81, 83]. As the PVC template showed significant increase in the number of PVCs with documented size, site, removal and complete documentation it might be appropriate to further develop and evaluate the template in order to continue to increase the accuracy and completeness of PVC documentation.

## **7.2 PVC-RELATED COMPLICATIONS**

The results from paper II showed that infiltration was the most common complication of PVCs, which is in accordance with other studies among paediatric patients [89-97]. The occurrence of infiltration in paper II at 14.4% was however slightly lower compared to previous studies [89-97] and the occurrence of occlusion at 13.4% was within the range of previous studies [91, 93, 94, 96, 97, 102]. The results from paper II also showed that infiltration occurred more frequently in neonatal than paediatric patients. Previous studies have been inconclusive as to whether younger patients are more likely to be affected by infiltration [90, 92, 95, 97]. As younger patients cannot verbally express discomfort or pain, it is important that RNs regularly inspect insertion sites as well as perform PVC function controls. The use of pain assessment scales adapted for preverbal children may be of value in order to detect and evaluate early signs and symptoms of PVC-related complications, such as discomfort and pain.

PVCs in paediatric care should stay *in situ* until removal is clinically indicated, which means that there will always be early signs or symptoms of complications in paediatric healthcare. This also indicate that frequent assessments of whether the PVC should remain *in situ* or be removed is essential. This implies that PVCs must be removed immediately if the patient develops signs and symptoms of complications, if the PVC is malfunctioning or if it is no longer needed. Even though PVC insertion may be challenging in neonatal and paediatric patients, PVCs should never be left in place on a just in case basis. It is a concern that RNs' adherence to daily inspection of PVC insertion site was so low (papers III, IV), as inspection is an important strategy to detect early signs and symptoms so that complications such as infections, necrotic of the skin and thrombophlebitis can be avoided.

Though healthcare professionals and healthcare organisations are obliged to report and investigate adverse events or preventable adverse events, there was no available data on PVC-related complications in any of the hospital's local incidence reporting systems. It can only be speculated to why PVC-related complications are not reported, it might be that they are regarded as less serious events as they are a natural consequence of having a PVC *in situ*. Other studies have shown that there is a wide underreporting of adverse events in incident reporting systems [116-122], which imply that many events, like PVC-related complications, might go unnoticed. Several PVC-related complications are preventable adverse event as they may be avoided if for example, inspection of PVC insertion site were performed regularly. If PVC-related complications were treated as adverse events, they would probably be reported and investigated more frequently so that similar events could be prevented in the future.

### **7.3 THE INFLUENCE OF WORK CONTEXT**

A successful implementation of the CPG recommendations as computer reminders would more likely occur, according to the PARIHS, if the evidence and the context were perceived as high among the RNs.

#### **7.3.1 Evidence for the CPG**

According to PARIHS, evidence is high when it has a sound research base and coincide with clinical and patient experiences [32]. The CPG included altogether eleven references to research articles, out of which three were systematic reviews, one meta-analysis, two randomised controlled trials and the remaining five were single site descriptive studies. The meta-analysis included only one article with paediatric patients and one of the randomised controlled trails had not conducted a sample size calculation and the other did not include a sample size that secured statistical power. Five of the included articles were studies on paediatric populations, and none of these were referred to when recommending choice of PVC site, size or related complications. The CPG could most likely have included more references to thorough studies on paediatric populations that investigated and evaluated PVC

insertion, management and signs and symptoms of complications. Professional experience was referred to when recommending PVC sites that should be avoided and the CPG referred to articles concerning how anxiety among paediatric patients and their carers could be managed before, during and after PVC insertion. The CPG also stated that paediatric patients should be given the opportunity to be involved in their own treatment and that children who are hospitalised have the right to receive age appropriate information before PVC insertion. However the CPG contained no information or references on how this information could be given to patients of different ages. This could have been appropriate, as research has shown that PVC insertion is one of the most painful and stressful procedures among paediatric patients [123], and that it is a time consuming procedure for staff [84, 86, 124]. The CPG recommended that patients and their carers should be informed about possible signs and symptoms of PVC-related complications before insertion so that they can report any changes related to the PVC. The CPG could most likely have included more recommendations concerning successful factors as well as known risk factors for PVC access [84, 125, 126], and the evidence regarding strategies for preventing PVC-related complications were scarce.

The research base for the CPG could most likely have been more robust and the experiences from healthcare professionals and patients could have been more explicit. Unfortunately, we do not have any data on how RNs perceived the CPG for PVCs, but it is a concern that approximately 30-40% of the RNs stated that they did not know about the CPGs for venous catheters (papers III, IV). The findings concerning RNs awareness of the CPG concur with previous studies, namely that the implementation strategy of posting CPGs on a web site, which was the hospitals implementation plan, is an ineffective strategy for guideline dissemination [127].

### **7.3.2 Context**

The assumption, according to PARIHS, is that the more favourable the context, the better the conditions for successful implementation. A context that is scored high by RNs is more receptive to change as it represents a more sympathetic culture, stronger leadership and appropriate evaluative systems [34]. Most RNs scored their context (leadership, culture and evaluation) as moderately low or moderately high (paper IV), which indicates that the conditions were probably not optimal for the intervention in paper IV to be successful.

RNs scores for leadership were almost equally divided into high or low (paper IV). Previous research has clearly demonstrated the importance of leadership to support EBP [128-131] and that leadership at all levels of an organisation has been identified to influence RNs' use of CPGs [132]. Studies in Sweden have also shown that Nurse Managers' lack of academic education, research use and failure to support research use have been linked too less EBP activities among RNs [133-135]. Leadership did not show any significant associations with the adherence the CPG recommendations (paper III) and one can only speculate why an

association was lacking. Leadership influences the work context on a unit, for example Nurse Managers are in charge of the resources and are thus responsible for creating conditions that affect evaluation and the availability of information resources [35]. In other words, leadership is probably also expressed in some of the other dimensions of the ACT such as, evaluation, information sharing activities, social processes, and structural and electronic resources.

Culture was scored high by RNs in both paper III and IV though RNs in the intervention group scored their culture significantly higher compared to the control group (paper IV). Culture is defined as the forces at work, which give the physical environment a character and a feel [32]. The hypothesis is that a culture that is scored high has clarity of values and beliefs and a consistency in valuing relationships, teamwork, power and authority and where recognition and rewards are provided [35]. RNs' mean scores, individually and aggregated to unit level, were highest for information sharing social processes (paper III), which is described as active connections among people, which reflect trust, mutual understanding and shared values and behaviors. The items concerning this dimension in the ACT included the willingness between RNs and units to share information and if RNs felt that managers took their observations and concerns seriously. The high scores for the context dimensions of culture and social sharing processes indicate that there was a good climate among RNs at the hospital, where values, beliefs and support for each other was perceived as very strong.

Evaluation was scored low by a majority of the RNs in both the intervention and control group (paper IV). It is a great concern that RNs scored regular evaluation low as it was significantly related to daily inspection of PVC insertion site (paper III). A Cochrane review indicate that audit and feedback might be more effective when baseline performance is low, when the source is a supervisor or a colleague and when the information is provided more than once both verbally and in writing [136]. The authors conclude that audit and feedback often lead to small but potentially important improvements in professional practice and that both explicit targets and an action plans should be included. As adherence to CPGs most often has an impact on patients' outcomes, it is essential that RNs are informed about the complication rates related to PVCs as these events are preventable if discovered on time. It might be interesting to further investigate if timely feedback and discussions of CPG adherence and of complication rates might influence RNs' clinical decision-making concerning PVCs.

The findings concerning the context dimensions included in the PARIHS framework, namely that culture was perceived as high and that both leadership and evaluation could be higher show promising improvement potentials. It could be argued that the increase of regular evaluation systems to RNs is easier to change than to change an entire culture at a unit or a hospital. Further efforts to investigate the characteristics among the Nurse Managers that received high scores should be undertaken so that these features can be supported and evaluated in the future.



### **7.3.3 Context and RNs characteristics in relation to CPG adherence**

The analysis showed that information sharing activities and fewer years since nursing certificate was significantly related to the use of disposable gloves (paper III). It should, however, be noted that information sharing activities showed a Cronbach's  $\alpha$  of 0.60, indicating some uncertainty in the reliability of this dimension (paper III). Another study has shown identical result concerning the Cronbach's  $\alpha$  for this dimension, which the authors describe could be explained by the fact that the items addresses concepts that are broader and perhaps more subject to individual interpretation, than the items in the remaining context dimensions [53]. A more recent study on the influence of context on RNs use of research in paediatric hospitals showed that information sharing interactions and activities as well as organisational slack (space) were important predictors, in addition to the core context dimensions in the PARIHS framework [56]. The authors conclude that unit managers ought to increase activities where interaction and observation of peers and senior hospital staff are possible, but also that these activities should be incorporated into interventions. Attitudes towards research and attendance at conferences and/or in-services are two characteristics that can and should be the focus of future research utilisation interventions [137].

It is a concern that more senior RNs did not adhere to the CPG recommendation of disposable gloves (paper III). The study by Erasmus et al. [138] on the reasons for poor hand hygiene among RNs, medical students, and physicians in hospital settings showed that the examples set and norms established by senior staff were of major importance for hand hygiene compliance among junior staff. Their study showed that if it was accepted that senior staff deviated from the set of rules concerning hand hygiene, it would result in junior staff showing lower adherence to the hand hygiene guidelines. Based on the result from Erasmus et al. it might be appropriate to address the lower use of disposable gloves among more senior RNs before introducing initiatives or interventions that stimulate interactions and observations between junior and senior RNs.

The results from paper III also showed that the use of structural and electronic resources had a positive association with RNs' adherence to disinfection of hands. This context dimension covers various sources of information and knowledge and is designed to measure factors that facilitate access to and the use of knowledge, including library resources, CPGs, in-service education, and the Internet [53]. This dimension had a mean score of 5.1 on an 11-point scale, which indicates that further efforts can be made in order to increase RNs availability and use of such resources.

### **7.3.4 Staff turnover**

The criticism of the PARIHS framework is that it is not clear what role individuals play as part of the interaction between evidence and context [139] and that the influence of staff turnover is not included [140]. The influence of RNs individual characteristics has already been discussed as an important factor that influenced the adherence to use disposable gloves.

Wallin et al. [13] state that when the staff turnover of RNs is high it creates a situation where the novice RN all too soon can become ‘the most experienced’, which adds to a demanding work context. When examining the number of eligible respondents for the questionnaire (excluding RNs that performed administrative duties, were on parental leave, sick leave or studied full time) that was handed out at baseline and post-intervention (paper IV), the total percentage of RNs that were still working post-intervention at all units were 46.0% (n=151). The percentage of RNs that was still working post-intervention in the intervention and control group was 47.4% (n=83), and 44.4% (n=68), respectively. The variation of RNs that was still working post-intervention at the intervention units ranged from 39.1% to 80% and from 25.0% to 64.3% at the control units. The high prevalence of staff overturn indicates that there is a great need to establish structured and standardised routines not only for documentation but also for the implementation and dissemination of CPGs.

## **7.4 THE COMPUTER REMINDERS**

Grimshaw [4] argues that it is essential that knowledge translators identify key messages for different audiences and design these messages in languages and products that are easily assimilated. There are few healthcare settings that take advantage of what electronic systems have to offer and continue to construct CPGs in terms of layout and design as if they were to be printed. Ineffective strategies of CPG dissemination have shown to include didactic education and passive dissemination strategies such as posting guidelines on a web site, or providing the guideline to healthcare professionals in printed form [127].

A systematic review on factors that differentiated between effective and ineffective CDSS in terms of improvement on process of care or patients’ outcomes were published after the implementation of the computer reminders in paper IV [141]. The authors of that review conclude that CDSS that only advised healthcare professionals at the point of care were not significantly associated with success, which earlier reviews had demonstrated [64, 142]. The review showed however that systems that provided advice to both patients and healthcare professionals were more likely to succeed as well as CDSS that required the users to provide a reason for deviating from recommendations. Their results showed that interactive CDSS seems to be more successful than CDSS that simply provide advice to healthcare professionals. Though the idea of the intervention in paper IV was to evaluate a relatively simple form of reminders, that just advised RNs, it might have, in light of the more recent reviews, been too basic.

To differentiate between junior and senior RNs has shown to be of importance when developing strategies to increase EBP among RNs [143]. Studies have shown that RNs with a higher educational level, such as a Master’s degree or qualifications at an advanced level, have reported a higher extent of EBP compared with RNs with lower qualifications [144, 145]. Moreover, junior RNs have reported more barriers compared with senior RNs in regard to accessing organisational information such as CPGs, protocols, evidence-based resources as

well as having the time to practise EBP [143]. The median number of years since nursing certificate and the RNs median years at their current units went down for both groups post-intervention compared to baseline (paper IV). Between 34-48% the RNs (paper IV) had an advanced nursing degree meaning that the majority of RNs were lacking specialised training in for example paediatric care. A case site analysis concerning RNs' use of CDSS systems in England showed that RNs' experience of their workplace and their experience of using a specific CDSS influenced how they use the system to inform their decisions. The results showed that RNs used CDSS to inform their decision in situations they had little experience of and relied on their own expertise to form decisions in situations they were more familiar with [146]. Another study showed that less experienced RNs were more likely to follow recommendations from a CDSS when making decisions in practice [147]. An alternative strategy for the computer reminders in paper IV could have been to deliberately target and construct them so that they guided newly graduated and recently employed RNs, as they seem more likely to benefit from such recommendations.

Authors of a recent published overview of systematic reviews conclude that there is no convincing evidence that multifaceted interventions are more effective than single-component interventions in changing healthcare professionals' behaviours. The authors however argue that it might be appropriate to design single or less complex multifaceted interventions that are tailored to overcome contextual barriers and improve the targeted behaviour [148]. Studies that have shown some positive outcomes concerning the use of CDSS in nursing practice in recent years have in addition to CDSS also included educational sessions [149, 150] and/or feedback [151]. A study conducted in an emergency department, conclude that a multifaceted intervention, including education, audit and real-time feedback, seemed to increase and sustain compliance with PVC care processes and improve RNs' knowledge [152]. The intervention in paper IV did not include one of the cornerstones in the PARIHS framework, namely facilitation, as the idea was to investigate if the computer reminders could substitute more complex and expensive strategies such as facilitators or educational sessions. However, the results from more recent studies indicate that the intervention might have benefitted from being accompanied by a tailored intervention where for example specific barriers at the inpatient units were targeted. The results from the papers included in this thesis indicate that potential barriers that need to be targeted at the paediatric hospital are the low frequency of documented reasons for PVC removal, the low adherence to inspection of PVC insertion site and the lack of regular evaluation to RNs.

The location of the PVC template and the reminders in the EPR might have been improved, as it took the RNs three clicks in the EPR to get there. On the other hand, the template was not in an unfamiliar location in the EPR. RNs had to get to the same location in order to document, for example, patients' body temperature, weight, height and blood pressure. However, the pure existence of the PVC template and the reminders might have unfortunately been unknown for a number of RNs. There were several recommendations in the computer reminders that the RNs could have improved over time, but for which there are no data. For

example, disinfection of PVC insertion area, the use aseptic technique when managing PVCs or catheter systems as well as the choice of PVC size.

According to Steckler and Linnan [153] process evaluation - the degree to which an intervention was implemented as designed - should be a part of the evaluation of public healthcare interventions. To identify for whom the intervention was effective, and under what conditions the intervention was effective is according to them crucial. Key process evaluation components include context, reach, dose delivery, dose received, fidelity, implementation and recruitment. Context can either directly or indirectly affects the intervention and reach, refers to the degree to which the intended audience participated in the intervention. The amount or proportion of the intervention that was actually delivered to the participants is referred to as dose delivered, while dose received assesses the extent of engagement among the participants with the intervention. Fidelity address whether the intervention was carried out according to plan and implementation includes a combination of reach, dose delivered, dose received and fidelity. Recruitment examines the resources needed and the reasons for nonparticipation. As mentioned earlier, RNs scores of their work context indicated that the conditions were probably not optimal for the intervention with the computer reminders. However, this thesis cannot report if and how the context at the different intervention units affected the computer reminders or how many of the RNs that documented PVCs in the template and were thereby exposed to the reminders. Neither can it describe how the RNs perceived the reminders that pop-up when they were documenting PVCs. A study, that is not part of this thesis, have observed and interviewed RNs at the intervention units concerning their awareness of the PVC template, the computer reminders, their management of PVCs and their adherence to the CPG recommendations. Data for this study have been collected and evaluated, but are not yet published.

## **7.5 METHODOLOGICAL CONSIDERATIONS**

The papers presented in this thesis employed different quantitative methods in order to evaluate the effects of implementing recommendations from a CPG for PVCs as reminders in EPRs and to describe factors of importance for the implementation process and outcomes. Data has been collected through observations of patients with PVCs, EPRs and questionnaire to RNs.

For the observations of patients with PVCs in paper I , inter-rater reliability was evaluated by comparing examinations of 20 colour photographs of PVCs by the two observers and one expert in PVC care: Cohen's kappa coefficient was ( $K= 0.71$ ) [154]. This kappa value is according to Altman [155] classified 'Good agreement' as it is ranges between 0.61-0.80.

Some limitations should be taken into account as PVC characteristics and related complications were based on retrospective record data, and reasons for removals were assessed by a number of bedside RNs (papers II, IV). PVC characteristics and related

complications was based on individual RNs' observations and recordings, and it cannot be verified if the recorded reason for removal was the accurate reason for removal or the exact number of real PVC-related complications. It should also be mentioned that the documentation might have improved over time, which could result in an increase in recorded PVC-related complications. This should however not affect the outcome as the shortcoming of the PVC recording and related complications should be equally distributed in the intervention and control group due to the randomisation (paper IV). It should also be mentioned that there are no data on possible patient-related factors (i.e., the child's diagnosis/condition and type of pharmacological treatment administered via the PVC) that could have influenced the complication rate.

Several PVCs had incomplete documentation and were therefore excluded (papers II, IV), which can lead to risks of either underestimation or overestimation of the number of complications. PVC-related complications may also have occurred a few days after the removal of the PVC and would therefore not be included as the audit of EPRs ended the day PVC removal was documented. The findings in paper II were somehow similar to other studies concerning PVC-related complications, but caution should be given to the fact that previous studies collected data through observations of PVCs. Another consideration is that other studies have present PVC-related complication rates and not complications per 1000 catheter days, which makes it difficult to compare results across studies.

The response rate among RNs in paper III was 58.4% and 65.4% at baseline and 71.5% post-intervention for paper IV. Unfortunately, we do not have access to any data for the non-responders of the questionnaire. One should keep in mind that the study is based on self-reported data, and therefore there is a risk for social desirability, which might have led to over-reporting of preferred procedures for the management of PVCs [156]. However, it does not seem that social desirability has affected the outcome to a high extent, as ratings of adherence to the use of disposable gloves and daily inspection of the PVC site were low.

## 8 CONCLUSIONS

The overall findings from the four papers in this thesis can briefly be concluded as:

- The EPR did not provide accurate data on PVCs either before or after the implementation of a PVC template.
- PVC-related complications, especially infiltration and occlusion were common, particularly among younger aged patients.
- Work context, in the form of structural and electronic resources, information sharing activities, and evaluation were in different ways associated with RNs' adherence to the CPG recommendations.
- Most RNs adhered to the recommendation concerning disinfection of hands, while the use of disposable gloves and daily inspection of PVC insertion site showed greater improvement potential.
- The computer reminders did not have any significant effect on PVC-related complications, nor on RNs' adherence to the CPG recommendations.
- The context in both groups varied from moderately low to moderately high, indicating that a successful implementation was probably less likely to occur.

## 9 IMPLICATIONS FOR CLINICAL PRACTICE

To evaluate and improve the quality in management of PVCs, it is essential that RNs document the care given in a structured and standardised way. Quality registers could easily be constructed if insertion date, side, site, size, removal date and reason for removal were documented consistently in a standardised manner.

The results from paper II could be of use for the management of PVCs, as there were few PVC-related complications when they were inserted into the dorsum of the hand and that PVC insertion near a joint was a risk factor for complications. Also that infiltration was more common in younger patients and that regular inspections and function controls are of high importance, as these patients cannot verbally describe the location of discomfort and pain.

For healthcare management, the findings from paper IV, indicated that the CPG for PVCs could be further improved by including more robust research concerning paediatric care as well as include more studies to enhance the experiences from healthcare professionals and patients. The findings from paper III also suggest that the lower adherence to the use of disposable glove by senior RNs is something that needs to be addressed as research has shown that senior staff members adherence influences more junior staff members. Greater opportunities for interaction with and observation of peers and senior hospital staff could also be encouraged, as this seems to facilitate the adherence to disposable gloves. In addition increased use of structural and electronic resources as defined in the ACT seems to have a positive influence on RNs' adherence to disinfection of hands. Regular audits of PVC-related complications would be useful and timely feedback of the results should be given to staff, as it seems to promote daily inspections of PVC insertion site.

## 10 FUTURE RESEARCH

There is a need to further investigate the usability and impact of standardised and structured documentation for RNs. Data on PVCs for paper I was collected from all possible locations within the EPR and it would be valuable to further examine how frequently the PVC template was used in order to document PVCs. More knowledge on how to standardise and structure RNs documentation may not only improve the accuracy but also facilitate the evaluation of interventions that target RNs and patient outcomes.

As infiltration was more common in younger patients it would be of interest to further investigate the use of pain assessment scales in order to evaluate early signs and symptoms of PVC-related complications, such as discomfort and pain. There is also a clear need for further comprehensive prospective studies regarding overall PVC-related complications and related risk factors in paediatric care. A final evaluation could assess if timely feedback and discussions of CPG adherence and PVC-related complication rates might influence RNs' clinical decision-making concerning PVCs.

Other important questions for future research are which contextual factors that facilitate RNs adherence and use of CPGs, as well as how tailored interventions can be based on contextual knowledge so that barriers can be more easily targeted. To further investigate how computer reminders that advise both patients and healthcare professionals within paediatric hospital settings could be designed and evaluated. It would be useful to examine if and how reminders directed to newly graduated and employed RNs could support and enhance their EBP activities.



## 11 ACKNOWLEDGEMENTS

First I would like to thank my supervisors that have been with me for these last years. Anna Ehrenberg, Lars Wallin, Britt-Marie Ygge, Maria Unbeck and Eva Johansson.

Anna, your ability to process text and manuscript is a talent that I have had the fortune to experience and I am still learning. You have dedicated the time and effort to help me continue to reflect and articulate what it is that can and should be said.

Lars, thank you for taking me on this knowledge translation and context journey. You have the ability to reflect on the bigger pictures when we have been occupied with details. You have a way of formulating questions and concerns in a very pleasant way combined with the fact that you can be straightforward and just say, I do not understand.

Britt-Marie, you gave me the chance and responsibility to develop the first CPGs for central venous catheters that later led to this PhD project. Thank you for believing in me!

Maria, aka hawk eye, you see details like no one else. I couldn't have asked for a better person to work with during the data collection and data cleansing. It is an absolute pleasure to work with you and you have become a really dear friend of mine that I intend to keep for a very long time.

Eva, you passed away too soon. It has been a privilege to work with you and being able to take part of your methodical and comprehensive ways of dealing with research questions. Your constant curiosity and drive to understand has been incredibly inspiring.

I would also like to direct a special thank you to the co-author, Max Petzold. You are an incredible pedagogical and patient person.

To the wonderful people whose paths I have crossed during the years.

The crazy and most creative times I have ever had were in a tiny room with Anna-Carin Magnusson and Björn Tingberg. We are a living proof that creativity, a huge amount of humour and constant chattering can be combined with serious research and brilliant ideas.

AnnaMaria Tollne, we have been by each other's side since the beginning of this journey, and oh my it has been an adventurous journey. I am incredibly grateful to have you as a friend and really proud to call you my colleague. You are a force to be reckoned with!

To Synnöve Lindemalm, Per Nydert, Åsa Andersson, Ranaa el Edelbi, Anders Nordqvist, Kicki Malmqvist, Kristina Walfridsson and Maria Ödling with whom I shared a corridor with. Thank you for remarkably creative lunch conversations, laughter, songs and humming (Åsa). Friday lunch disco, coffee breaks, mental breaks and forward thinking. I am grateful that I got to know you and privileged to have been worked with you all. A special thank you

to Synnöve for the brilliant idea to create and include insertion time in the regression analyses for paper II.

Karin Hegland and Malin Signahl, I'm proud to call you my former colleagues and newfound friends. Thank you for all the great conversations, ideas and support, you are brilliant! The fact that we manage to accomplish so much in such a short time still amazes me.

Nina Andersson, thank you for your kind words and encouragement. It is a privilege to call you my colleague and I'm really looking forward to work with you.

Irini Antoniadou, you are one of these people that it is so incredibly easy to like, you are kind, considerate and wise. I am so glad that our paths crossed!

There are a few people that I would like to give extra credit to, as you were with me during my most difficult times. Stina Salmi, do not think I can thank you enough for what you did for me. I know that you went beyond your professional duties in order to support me, and I am forever grateful for that. Ann Ahnelöv, you went far beyond your professional obligations and stepped in when I desperately needed help. The fact that you noticed and acted still makes me humble and extremely thankful.

To my friends, that I intend to spend much more time with, thank you for still being there though I have been pretty absent.

Märta Åberg, thank you for always being there and for getting me out on the soccer field again to play with the great ladies in team GAMarna. Tove Johansson and Erik Bäckström, without whom I would most likely not have met Johan. We or I owe you several dinners and catch up time. Helena Lindfors Nybom, you are an inspiration and force with whom I intend to spend much more time with. I love our rendezvous where everything just takes off and anything is possible. Loti (Charlotta Langenskiöld), whenever things get tough, I imagine us sitting on that porch, where I'm in charge of the flowers and you the baking. You are and will always be my auton ajokortin, my mintkrokant and Mumin.

A massive thank you to my family Mum, Dad, Jojo, Helena, Hampus, Hugh (I owe you a cake), Ian, Bella and the wonderful kids Leah (chose you present), Holly, Lucas and Otis who have participated as models, actors, painters and calligraphers to my work over the last years. You are my most solid support and foundation, without you I wouldn't be me.

To Jampe, Sonia and Hillevi, thank you for including me in your wonderful family. A special thank you to Hillevi for designing and creating the book cover to this thesis, you are brilliant!

The best part of this whole journey is that I met Johan. You have been an incredible support and a source of comfort. I'm incredibly proud and lucky to have you in my life and I intend to keep you there forever. Love you!

## 12 REFERENCES

1. SFS 2010:659 Patientsäkerhetslag, (2010).
2. Evidence-Based Medicine Working Group. Evidence-based medicine. A new approach to teaching the practice of medicine. *JAMA*. 1992;268(17):2420-5.
3. Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. *BMJ*. 1996;312(7023):71-2.
4. Grimshaw JM, Eccles MP, Lavis JN, Hill SJ, Squires JE. Knowledge translation of research findings. *Implement Sci*. 2012;7:50.
5. Sung NS, Crowley WF, Genel M, Salber P, Sandy L, Sherwood LM, et al. Central challenges facing the national clinical research enterprise. *JAMA*. 2003;289(10):1278-87.
6. Schuster MA, McGlynn EA, Brook RH. How good is the quality of health care in the United States? *Milbank Q*. 1998;76(4):517-63, 09.
7. Grol R. Successes and Failures in the Implementation of Evidence-Based Guidelines for Clinical Practice. *Medical Care* 2001; 39 (8, Supplement 2): 46-54.
8. Sveriges Kommuner och Landsting (SKL). Nationell stasning för ökad patientsäkerhet. Patientsäkerhet lönar sig Kostnader för skador och vårdskador i slutenvården. 2014.
9. Wilson RM, Runciman WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD. The Quality in Australian Health Care Study. *Med J Aust*. 1995;163(9):458-71.
10. Socialstyrelsen. Statistik om hälso- och sjukvårdspersonal. Officiell statistik om antal legitimerade (2013) och arbetsmarknadsstatus (2012). 2014.
11. Squires JE, Hutchinson AM, Boström AM, O'Rourke HM, Cobban SJ, Estabrooks CA. To what extent do nurses use research in clinical practice? A systematic review. *Implement Sci*. 2011;6:21.
12. Forsman H. Registered Nurses' reserach use. A national survey on extern, patterns, intentions and associated factors in undergraduate education and the first years in clinical practice: Karolinska Institutet; 2011.
13. Wallin L, Gustavsson P, Ehrenberg A, Rudman A. A modest start, but a steady rise in research use: a longitudinal study of nurses during the first five years in professional life. *Implement Sci*. 2012;7:19.
14. Rudman A, Gustavsson P, Ehrenberg A, Boström AM, Wallin L. Registered nurses' evidence-based practice: a longitudinal study of the first five years after graduation. *Int J Nurs Stud*. 2012;49(12):1494-504.
15. Estabrooks CA. Will evidence-based nursing practice make practice perfect? *Can J Nurs Res*. 1998;30(1):15-36.
16. Estabrooks CA, Chong H, Brigidear K, Profetto-McGrath J. Profiling Canadian nurses' preferred knowledge sources for clinical practice. *Can J Nurs Res*. 2005;37(2):118-40.
17. Squires JE, Moralejo D, Lefort SM. Exploring the role of organizational policies and procedures in promoting research utilization in registered nurses. *Implement Sci*. 2007;2:17.

18. Thompson C, Cullum N, McCaughan D, Sheldon T, Raynor P. Nurses, information use, and clinical decision making--the real world potential for evidence-based decisions in nursing. *Evid Based Nurs.* 2004;7(3):68-72.
19. Kajermo KN, Boström AM, Thompson DS, Hutchinson AM, Estabrooks CA, Wallin L. The BARRIERS scale -- the barriers to research utilization scale: A systematic review. *Implement Sci.* 2010;5:32.
20. Brouwers MC, De Vito C, Bahirathan L, Carol A, Carroll JC, Cotterchio M, et al. Effective interventions to facilitate the uptake of breast, cervical and colorectal cancer screening: an implementation guideline. *Implement Sci.* 2011;6:112.
21. Dogherty EJ, Harrison MB, Baker C, Graham ID. Following a natural experiment of guideline adaptation and early implementation: a mixed-methods study of facilitation. *Implement Sci.* 2012;7:9.
22. Field M, Lohr K. Clinical practice guidelines: Directions for a new program. Washington, D.C. National Academy press; 1990.
23. Medves J, Godfrey C, Turner C, Paterson M, Harrison M, MacKenzie L, et al. Systematic review of practice guideline dissemination and implementation strategies for healthcare teams and team-based practice. *Int J Evid Based Healthc.* 2010;8(2):79-89.
24. Vårdhandboken. <http://www.vardhandboken.se> 2015.
25. Burnes B. Emergent change and planned change – competitors or allies? *International Journal of Operations & Production Management.* 2004;24(9):886-902.
26. Grol R. Personal paper. Beliefs and evidence in changing clinical practice. *BMJ.* 1997;315(7105):418-21.
27. Graham ID, Logan J. Innovations in knowledge transfer and continuity of care. *Can J Nurs Res.* 2004;36(2):89-103.
28. Rogers E. *Diffusion of Innovations*, 5th ed. New York: The Free Press; 2003.
29. Green LW, Kreuter MW. *Health education planning: A diagnostic approach* (3rd ed.): Mountain View, CA: Mayfield.; 1999.
30. Green LW, Kreuter MW, Deeds SG, Partridge KB. *Health education planning: A diagnostic approach.* . Mountain View, CA: Mayfield.1980.
31. Logan J, Graham ID. Toward a comprehensive interdisciplinary model of health care research use. . *Science Communication.* 1998 20 (2, December ):227-46.
32. Kitson A, Harvey G, McCormack B. Enabling the implementation of evidence based practice: a conceptual framework. *Qual Health Care.* 1998;7(3):149-58.
33. Rycroft-Malone J, Kitson A, Harvey G, McCormack B, Seers K, Titchen A, et al. Ingredients for change: revisiting a conceptual framework. *Qual Saf Health Care.* 2002;11(2):174-80.
34. Rycroft-Malone J. The PARIHS framework--a framework for guiding the implementation of evidence-based practice. *J Nurs Care Qual.* 2004;19(4):297-304.
35. McCormack B, Kitson A, Harvey G, Rycroft-Malone J, Titchen A, Seers K. Getting evidence into practice: the meaning of 'context'. *J Adv Nurs.* 2002;38(1):94-104.

36. Campbell NC, Murray E, Darbyshire J, Emery J, Farmer A, Griffiths F, et al. Designing and evaluating complex interventions to improve health care. *BMJ*. 2007;334(7591):455-9.
37. Harvey G, Loftus-Hills A, Rycroft-Malone J, Titchen A, Kitson A, McCormack B, et al. Getting evidence into practice: the role and function of facilitation. *J Adv Nurs*. 2002;37(6):577-88.
38. Wallin L, Estabrooks CA, Midodzi WK, Cummings GG. Development and validation of a derived measure of research utilization by nurses. *Nurs Res*. 2006;55(3):149-60.
39. Estabrooks CA, Midodzi WK, Cummings GG, Wallin L. Predicting research use in nursing organizations: a multilevel analysis. *Nurs Res*. 2007;56(4 Suppl):S7-23.
40. Cummings GG, Hutchinson AM, Scott SD, Norton PG, Estabrooks CA. The relationship between characteristics of context and research utilization in a pediatric setting. *BMC Health Serv Res*. 2010;10:168.
41. Van Bogaert P, Clarke S, Roelant E, Meulemans H, Van de Heyning P. Impacts of unit-level nurse practice environment and burnout on nurse-reported outcomes: a multilevel modelling approach. *J Clin Nurs*. 2010;19(11-12):1664-74.
42. Kutney-Lee A, McHugh MD, Sloane DM, Cimiotti JP, Flynn L, Neff DF, et al. Nursing: a key to patient satisfaction. *Health Aff (Millwood)*. 2009;28(4):w669-77.
43. McHugh M, Kelly LA, Smith HL, Wu ES, Vanak JM, Aiken LH. Lower mortality in Magnet hospitals. *J Nurs Adm*. 2013;43(10 Suppl):S4-10.
44. Estabrooks CA, Midodzi WK, Cummings GG, Ricker KL, Giovannetti P. The impact of hospital nursing characteristics on 30-day mortality. *Nurs Res*. 2005;54(2):74-84.
45. Lucero RJ, Lake ET, Aiken LH. Nursing care quality and adverse events in US hospitals. *J Clin Nurs*. 2010;19(15-16):2185-95.
46. Duffield C, Diers D, O'Brien-Pallas L, Aisbett C, Roche M, King M, et al. Nursing staffing, nursing workload, the work environment and patient outcomes. *Appl Nurs Res*. 2011;24(4):244-55.
47. Aiken LH, Clarke SP, Sloane DM, Lake ET, Cheney T. Effects of hospital care environment on patient mortality and nurse outcomes. *J Nurs Adm*. 2008;38(5):223-9.
48. Kelly D, Kutney-Lee A, Lake ET, Aiken LH. The critical care work environment and nurse-reported health care-associated infections. *Am J Crit Care*. 2013;22(6):482-8.
49. Aiken LH, Sermeus W, Van den Heede K, Sloane DM, Busse R, McKee M, et al. Patient safety, satisfaction, and quality of hospital care: cross sectional surveys of nurses and patients in 12 countries in Europe and the United States. *BMJ*. 2012;344:e1717.
50. McCormack B, McCarthy G, Wright J, Slater P, Coffey A. Development and testing of the Context Assessment Index (CAI). *Worldviews Evid Based Nurs*. 2009;6(1):27-35.
51. Every NR, Fihn SD, Sales AE, Keane A, Ritchie JR. Quality Enhancement Research Initiative in ischemic heart disease: a quality initiative from the Department of Veterans Affairs. QUERI IHD Executive Committee. *Med Care*. 2000;38(6 Suppl 1):I49-59.
52. Helfrich CD, Li YF, Sharp ND, Sales AE. Organizational readiness to change assessment (ORCA): development of an instrument based on the Promoting Action on Research in Health Services (PARIHS) framework. *Implement Sci*. 2009;4:38.

53. Estabrooks CA, Squires JE, Cummings GG, Birdsell JM, Norton PG. Development and assessment of the Alberta Context Tool. *BMC Health Serv Res.* 2009;9:234.
54. Estabrooks CA, Squires JE, Hutchinson AM, Scott S, Cummings GG, Kang SH, et al. Assessment of variation in the Alberta Context Tool: the contribution of unit level contextual factors and specialty in Canadian pediatric acute care settings. *BMC Health Serv Res.* 2011;11:251.
55. Scott SD, Grimshaw J, Klassen TP, Nettel-Aguirre A, Johnson DW. Understanding implementation processes of clinical pathways and clinical practice guidelines in pediatric contexts: a study protocol. *Implement Sci.* 2011;6:133.
56. Squires JE, Estabrooks CA, Scott SD, Cummings GG, Hayduk L, Kang SH, et al. The influence of organizational context on the use of research by nurses in Canadian pediatric hospitals. *BMC Health Serv Res.* 2013;13:351.
57. Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, et al. Effectiveness and efficiency of guideline dissemination and implementation strategies. *Health technology assessment.* 2004;8(6):iii-iv, 1-72.
58. Dogherty EJ, Harrison MB, Graham ID, Vandyk AD, Keeping-Burke L. Turning knowledge into action at the point-of-care: the collective experience of nurses facilitating the implementation of evidence-based practice. *Worldviews Evid Based Nurs.* 2013;10(3):129-39.
59. Grimshaw J, Eccles M, Thomas R, MacLennan G, Ramsay C, Fraser C, et al. Toward evidence-based quality improvement. Evidence (and its limitations) of the effectiveness of guideline dissemination and implementation strategies 1966-1998. *J Gen Intern Med.* 2006;21 Suppl 2:S14-20.
60. Kitson AL, Rycroft-Malone J, Harvey G, McCormack B, Seers K, Titchen A. Evaluating the successful implementation of evidence into practice using the PARiHS framework: theoretical and practical challenges. *Implement Sci.* 2008;3:1.
61. Cochrane Effective Practice and Organisation of Care Review Group (EPOC). EPOC Taxonomy 2002. Oslo, Norwegian Knowledge Centre for the Health Services. Retrived from <https://epoc.cochrane.org/epoc-taxonomy>
62. Shojania KG, Jennings A, Mayhew A, Ramsay CR, Eccles MP, Grimshaw J. The effects of on-screen, point of care computer reminders on processes and outcomes of care. *Cochrane Database Syst Rev.* 2009(3):CD001096.
63. Gordon R, Grimshaw J, Eccles M, Rowe R, Wyatt J. On-screen computer reminders: effects on professional practice and health care outcomes. *Cochrane Database of Systematic Reviews.* 1998;Issue 2.
64. Garg AX, Adhikari NK, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. *JAMA.* 2005;293(10):1223-38.
65. Randell R, Mitchell N, Dowding D, Cullum N, Thompson C. Effects of computerized decision support systems on nursing performance and patient outcomes: a systematic review. *J Health Serv Res Policy.* 2007;12(4):242-9.
66. Anderson JA, Willson P. Clinical decision support systems in nursing: synthesis of the science for evidence-based practice. *Comput Inform Nurs.* 2008;26(3):151-8.

67. Fossum M, Ehnfors M, Svensson E, Hansen LM, Ehrenberg A. Effects of a computerized decision support system on care planning for pressure ulcers and malnutrition in nursing homes: an intervention study. *Int J Med Inform.* 2013;82(10):911-21.
68. Cho I, Park I, Kim E, Lee E, Bates DW. Using EHR data to predict hospital-acquired pressure ulcers: a prospective study of a Bayesian Network model. *Int J Med Inform.* 2013;82(11):1059-67.
69. Lyerla F. Design and implementation of a nursing clinical decision support system to promote guideline adherence. *Comput Inform Nurs.* 2008;26(4):227-33.
70. Piscotty RJ, Jr., Kalisch B. The relationship between electronic nursing care reminders and missed nursing care. *Comput Inform Nurs.* 2014;32(10):475-81.
71. Thomas MJ, Schultz TJ, Hannaford N, Runciman WB. Mapping the limits of safety reporting systems in health care--what lessons can we actually learn? *Med J Aust.* 2011;194(12):635-9.
72. Unbeck M. Evaluation of retrospective patient record review as a method to identify patient safety and quality information in orthopaedic care: Karolinska Institutet; 2012.
73. World Health Organisation (WHO). WHO draft guidelines for adverse event reporting and learning systems. From information to action 2005. Retrieved from: [http://www.who.int/patientsafety/events/05/Reporting\\_Guidelines.pdf](http://www.who.int/patientsafety/events/05/Reporting_Guidelines.pdf)
74. SFS 2008:355 Patientdatalagen, Stockholm; Riksdagen 2008.
75. Sharp L, Klinga C, Hansson J, Sachs MA. (Electronic health records risk patient safety. Audit of medical records shows serious deficiencies in documentation). *Lakartidningen.* 2014;111(20):868-71.
76. Urquhart C, Currell R, Grant MJ, Hardiker NR. Nursing record systems: effects on nursing practice and healthcare outcomes. *Cochrane Database Syst Rev.* 2009(1):CD002099.
77. Gunningberg L, Dahm MF, Ehrenberg A. Accuracy in the recording of pressure ulcers and prevention after implementing an electronic health record in hospital care. *Qual Saf Health Care.* 2008;17(4):281-5.
78. Gunningberg L, Fogelberg-Dahm M, Ehrenberg A. Improved quality and comprehensiveness in nursing documentation of pressure ulcers after implementing an electronic health record in hospital care. *J Clin Nurs.* 2009;18(11):1557-64.
79. Ahlqvist M, Berglund B, Wirén M, Klang B, Johansson E. Accuracy in documentation - a study of peripheral venous catheters. *J Clin Nurs.* 2009;18(13):1945-52.
80. De Marinis MG, Piredda M, Pascarella MC, Vincenzi B, Spiga F, Tartaglini D, et al. 'If it is not recorded, it has not been done!?' consistency between nursing records and observed nursing care in an Italian hospital. *J Clin Nurs.* 2010;19(11-12):1544-52.
81. Thoroddsen A, Ehnfors M, Ehrenberg A. Content and completeness of care plans after implementation of standardized nursing terminologies and computerized records. *Comput Inform Nurs.* 2011;29(10):599-607.
82. Saranto K, Kinnunen UM. Evaluating nursing documentation - research designs and methods: systematic review. *J Adv Nurs.* 2009;65(3):464-76.

83. Saranto K, Kinnunen UM, Kivekäs E, Lappalainen AM, Liljamo P, Rajalahti E, et al. Impacts of structuring nursing records: a systematic review. *Scand J Caring Sci*. 2014;28(4):629-47.
84. Reigart JR, Chamberlain KH, Eldridge D, O'Brien ES, Freeland KD, Larsen P, et al. Peripheral intravenous access in pediatric inpatients. *Clin Pediatr (Phila)*. 2012;51(5):468-72.
85. Kennedy RM, Luhmann J, Zempsky WT. Clinical implications of unmanaged needle-insertion pain and distress in children. *Pediatrics*. 2008;122 Suppl 3:S130-3.
86. Goff DA, Larsen P, Brinkley J, Eldridge D, Newton D, Hartzog T, et al. Resource utilization and cost of inserting peripheral intravenous catheters in hospitalized children. *Hospital pediatrics*. 2013;3(3):185-91.
87. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control*. 2011;39(4 Suppl 1):S1-34.
88. Pettit J. Assessment of the infant with a peripheral intravenous device. *Adv Neonatal Care*. 2003;3(5):230-40.
89. Batton DG, Maisels MJ, Appelbaum P. Use of peripheral intravenous cannulas in premature infants: a controlled study. *Pediatrics*. 1982;70(3):487-90.
90. De Lima Jacinto AK, Avelar AF, Pedreira ML. Predisposing factors for infiltration in children submitted to peripheral venous catheterization. *J Infus Nurs*. 2011;34(6):391-8.
91. Franck LS, Hummel D, Connell K, Quinn D, Montgomery J. The safety and efficacy of peripheral intravenous catheters in ill neonates. *Neonatal Netw*. 2001;20(5):33-8.
92. Garland JS, Dunne WM, Havens P, Hintermeyer M, Bozzette MA, Wincek J, et al. Peripheral intravenous catheter complications in critically ill children: a prospective study. *Pediatrics*. 1992;89(6 Pt 2):1145-50.
93. Hetzler R, Wilson M, Hill EK, Hollenback C. Securing pediatric peripheral i.v. catheters--application of an evidence-based practice model. *J Pediatr Nurs*. 2011;26(2):143-8.
94. Machado AF, Pedreira MaL, Chaud MN. Adverse events related to the use of peripheral intravenous catheters in children according to dressing regimens. *Rev Lat Am Enfermagem*. 2008;16(3):362-7.
95. Phelps SJ, Helms RA. Risk factors affecting infiltration of peripheral venous lines in infants. *J Pediatr*. 1987;111(3):384-9.
96. Sheehan AM, Palange K, Rasor JS, Moran MA. Significantly improved peripheral intravenous catheter performance in neonates: insertion ease, dwell time, complication rate, and costs. *J Perinatol*. 1992;12(4):369-76.
97. Stanley MD, Meister E, Fuschuber K. Infiltration during intravenous therapy in neonates: comparison of Teflon and Vialon catheters. *South Med J*. 1992;85(9):883-6.
98. Foster L, Wallis M, Paterson B, James H. A descriptive study of peripheral venous catheters in patients admitted to pediatric unit in one Australian hospital. *J Infus Nurs*. 2002;25(3):157-67.
99. Nelson DB, Garland JS. The natural history of Teflon catheter-associated phlebitis in children. *Am J Dis Child*. 1987;141(10):1090-2.



100. Shimandle RB, Johnson D, Baker M, Stotland N, Karrison T, Arnow PM. Safety of peripheral intravenous catheters in children. *Infect Control Hosp Epidemiol*. 1999;20(11):736-40.
101. Tobin CR. The Teflon intravenous catheter: incidence of phlebitis and duration of catheter life in the neonatal patient. *J Obstet Gynecol Neonatal Nurs*. 1988;17(1):35-42.
102. Webb AA. Methods of intravenous therapy in preterm infants. *Issues Compr Pediatr Nurs*. 1987;10(4):215-21.
103. Garland JS, Nelson DB, Cheah TE, Hennes HH, Johnson TM. Infectious complications during peripheral intravenous therapy with Teflon catheters: a prospective study. *Pediatr Infect Dis J*. 1987;6(10):918-21.
104. Peter G, Lloyd-Still JD, Lovejoy FH. Local infection and bacteremia from scalp vein needles and polyethylene catheters in children. *J Pediatr*. 1972;80(1):78-83.
105. Ahlqvist M, Bogren A, Hagman S, Nazar I, Nilsson K, Nordin K, et al. Handling of peripheral intravenous cannulae: effects of evidence-based clinical guidelines. *J Clin Nurs*. 2006;15(11):1354-61.
106. CompuGroup Medical. Take Care, <http://profdoccare.se> 2015.
107. CliniSoft Corporation. CliniSoft, <http://www.clinisoft.com> 2015.
108. Lundgren A, Wahren LK, Ek AC. Peripheral intravenous lines: time in situ related to complications. *J Intraven Nurs*. 1996;19(5):229-38.
109. Couzigou C, Lamory J, Salmon-Ceron D, Figard J, Vidal-Trecan GM. Short peripheral venous catheters: effect of evidence-based guidelines on insertion, maintenance and outcomes in a university hospital. *J Hosp Infect*. 2005;59(3):197-204.
110. Donner A, Klar N. Design and Analysis of Cluster Randomization Trials in Health Research London: Edward Arnold.: 2000.
111. Ahlqvist M, Berglund B, Nordstrom G, Klang B, Wirén M, Johansson E. A new reliable tool (PVC assess) for assessment of peripheral venous catheters. *J Eval Clin Pract*. 2010;16(6):1108-15.
112. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. *American journal of infection control*. 2011;39(4 Suppl 1):S1-34.
113. Estabrooks CA, Squire J, Adachi A, Kong LPGN. Utilization of health research in acute care settings in Alberta Technical Report. . Alberta, Canada: University of Alberta.: 2008.
114. Gesar B. Är vårdorganisationen mogen för evidensbaserad omvårdnad? En pilotstudie med Alberta Context Tool (ACT). (Is the organization ready for evidence-based nursing? A translation and validation of the Alberta Context Tool and a description of nurses experience of work contextual in orthopedic care). Retrieved from <http://urn.kb.se/resolve?urn=urn:nbn:se:du-61802008>
115. Cummings GG, Estabrooks CA, Midodzi WK, Wallin L, Hayduk L. Influence of organizational characteristics and context on research utilization. *Nurs Res*. 2007;56(4 Suppl):S24-39.
116. Unbeck M, Muren O, Lillkrona U. Identification of adverse events at an orthopedics department in Sweden. *Acta Orthop*. 2008;79(3):396-403.

117. Williams DJ, Olsen S, Crichton W, Witte K, Flin R, Ingram J, et al. Detection of adverse events in a Scottish hospital using a consensus-based methodology. *Scott Med J*. 2008;53(4):26-30.
118. Naessens JM, Campbell CR, Huddleston JM, Berg BP, Lefante JJ, Williams AR, et al. A comparison of hospital adverse events identified by three widely used detection methods. *Int J Qual Health Care*. 2009;21(4):301-7.
119. Olsen S, Neale G, Schwab K, Psaila B, Patel T, Chapman EJ, et al. Hospital staff should use more than one method to detect adverse events and potential adverse events: incident reporting, pharmacist surveillance and local real-time record review may all have a place. *Qual Saf Health Care*. 2007;16(1):40-4.
120. Hogan H, Olsen S, Scobie S, Chapman E, Sachs R, McKee M, et al. What can we learn about patient safety from information sources within an acute hospital: a step on the ladder of integrated risk management? *Qual Saf Health Care*. 2008;17(3):209-15.
121. Classen DC, Resar R, Griffin F, Federico F, Frankel T, Kimmel N, et al. 'Global trigger tool' shows that adverse events in hospitals may be ten times greater than previously measured. *Health Aff (Millwood)*. 2011;30(4):581-9.
122. Christiaans-Dingelhoff I, Smits M, Zwaan L, Lubberding S, van der Wal G, Wagner C. To what extent are adverse events found in patient records reported by patients and healthcare professionals via complaints, claims and incident reports? *BMC Health Serv Res*. 2011;11:49.
123. Cummings EA, Reid GJ, Finley GA, McGrath PJ, Ritchie JA. Prevalence and source of pain in pediatric inpatients. *Pain*. 1996;68(1):25-31.
124. Barria RM, Lorca P, Munoz S. Randomized controlled trial of vascular access in newborns in the neonatal intensive care unit. *Journal of obstetric, gynecologic, and neonatal nursing : JOGNN / NAACOG*. 2007;36(5):450-6.
125. Larsen P, Eldridge D, Brinkley J, Newton D, Goff D, Hartzog T, et al. Pediatric peripheral intravenous access: does nursing experience and competence really make a difference? *Journal of infusion nursing : the official publication of the Infusion Nurses Society*. 2010;33(4):226-35.
126. Kuensting LL, DeBoer S, Holleran R, Shultz BL, Steinmann RA, Venella J. Difficult venous access in children: taking control. *Journal of emergency nursing: JEN : official publication of the Emergency Department Nurses Association*. 2009;35(5):419-24.
127. Prior M, Guerin M, Grimmer-Somers K. The effectiveness of clinical guideline implementation strategies-a synthesis of systematic review findings. *J Eval Clin Pract*. 2008;14(5):888-97.
128. Gifford W, Davies B, Edwards N, Griffin P, Lybanon V. Managerial leadership for nurses' use of research evidence: an integrative review of the literature. *Worldviews Evid Based Nurs*. 2007;4(3):126-45.
129. Gifford W, Davies B, Tourangeau A, Lefebvre N. Developing team leadership to facilitate guideline utilization: planning and evaluating a 3-month intervention strategy. *J Nurs Manag*. 2011;19(1):121-32.
130. Sandström B, Borglin G, Nilsson R, Willman A. Promoting the implementation of evidence-based practice: a literature review focusing on the role of nursing leadership. *Worldviews Evid Based Nurs*. 2011;8(4):212-23.

131. Wilkinson JE, Nutley SM, Davies HT. An exploration of the roles of nurse managers in evidence-based practice implementation. *Worldviews Evid Based Nurs.* 2011;8(4):236-46.
132. Davies B, Edwards N, Ploeg J, Virani T, Skelly J, Dobbins M. Determinants of the Sustained Use of Research Evidence in Nursing: Final Report. Canadian Health Services Research Foundation, Ottawa, ON Retrived from: [http://www.cfhi-fcass.ca/Migrated/PDF/ResearchReports/OGC/davies\\_final\\_e.pdf](http://www.cfhi-fcass.ca/Migrated/PDF/ResearchReports/OGC/davies_final_e.pdf) 2006.
133. Gunningberg L, Brudin L, Idvall E. Nurse Managers' prerequisite for nursing development: a survey on pressure ulcers and contextual factors in hospital organizations. *J Nurs Manag.* 2010;18(6):757-66.
134. Johansson B, Fogelberg-Dahm M, Wadensten B. Evidence-based practice: the importance of education and leadership. *J Nurs Manag.* 2010;18(1):70-7.
135. Kajermo KN, Undén M, Gardulf A, Eriksson LE, Orton ML, Arnetz BB, et al. Predictors of nurses' perceptions of barriers to research utilization. *J Nurs Manag.* 2008;16(3):305-14.
136. Ivers N, Jamtvedt G, Flottorp S, Young JM, Odgaard-Jensen J, French SD, et al. Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev.* 2012;6:CD000259.
137. Squires JE, Estabrooks CA, Gustavsson P, Wallin L. Individual determinants of research utilization by nurses: a systematic review update. *Implement Sci.* 2011;6:1.
138. Erasmus V, Brouwer W, van Beeck EF, Oenema A, Daha TJ, Richardus JH, et al. A qualitative exploration of reasons for poor hand hygiene among hospital workers: lack of positive role models and of convincing evidence that hand hygiene prevents cross-infection. *Infect Control Hosp Epidemiol.* 2009;30(5):415-9.
139. Rycroft-Malone J, Seers K, Chandler J, Hawkes CA, Crichton N, Allen C, et al. The role of evidence, context, and facilitation in an implementation trial: implications for the development of the PARIHS framework. *Implement Sci.* 2013;8:28.
140. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci.* 2009;4:50.
141. Roshanov PS, Fernandes N, Wilczynski JM, Hemens BJ, You JJ, Handler SM, et al. Features of effective computerised clinical decision support systems: meta-regression of 162 randomised trials. *BMJ.* 2013;346:f657.
142. Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ.* 2005;330(7494):765.
143. Gerrish K, Ashworth P, Lacey A, Bailey J. Developing evidence-based practice: experiences of senior and junior clinical nurses. *J Adv Nurs.* 2008;62(1):62-73.
144. Brown CE, Ecoff L, Kim SC, Wickline MA, Rose B, Klimpel K, et al. Multi-institutional study of barriers to research utilisation and evidence-based practice among hospital nurses. *J Clin Nurs.* 2010;19(13-14):1944-51.
145. Gerrish K, Guillaume L, Kirshbaum M, McDonnell A, Tod A, Nolan M. Factors influencing the contribution of advanced practice nurses to promoting evidence-based practice among front-line nurses: findings from a cross-sectional survey. *J Adv Nurs.* 2011;67(5):1079-90.

146. Dowding D, Mitchell N, Randell R, Foster R, Lattimer V, Thompson C. Nurses' use of computerised clinical decision support systems: a case site analysis. *J Clin Nurs*. 2009;18(8):1159-67.
147. Courtney KL, Alexander GL, Demiris G. Information technology from novice to expert: implementation implications. *J Nurs Manag*. 2008;16(6):692-9.
148. Squires JE, Sullivan K, Eccles MP, Worswick J, Grimshaw JM. Are multifaceted interventions more effective than single-component interventions in changing health-care professionals' behaviours? An overview of systematic reviews. *Implement Sci*. 2014;9:152.
149. Fossum M, Alexander GL, Ehnfors M, Ehrenberg A. Effects of a computerized decision support system on pressure ulcers and malnutrition in nursing homes for the elderly. *International journal of medical informatics*. 2011;80(9):607-17.
150. Hagiwara MA, Sjoqvist BA, Lundberg L, Suserud BO, Henricson M, Jonsson A. Decision support system in prehospital care: a randomized controlled simulation study. *Am J Emerg Med*. 2013;31(1):145-53.
151. Beeckman D, Clays E, Van Hecke A, Vanderwee K, Schoonhoven L, Verhaeghe S. A multi-faceted tailored strategy to implement an electronic clinical decision support system for pressure ulcer prevention in nursing homes: a two-armed randomized controlled trial. *International journal of nursing studies*. 2013;50(4):475-86.
152. Fakhri MG, Jones K, Rey JE, Takla R, Szpunar S, Brown K, et al. Peripheral venous catheter care in the emergency department: education and feedback lead to marked improvements. *Am J Infect Control*. 2013;41(6):531-6.
153. Steckler AB, Linnan L. Process evaluation for public health interventions and research. San Francisco ; [Great Britain]: Jossey-Bass; 2002.
154. Cohen J. A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*. 1960;20:37-46.
155. Altman D. Practical statistics for medical research. London: Chapman and Hall.; 1991.
156. Nichols A. An investigation of the division between espoused and actual practise in infection control and of the knowledge sources that may underpin this division. *British Journal of Infection Control*. 2008;9:11-5.